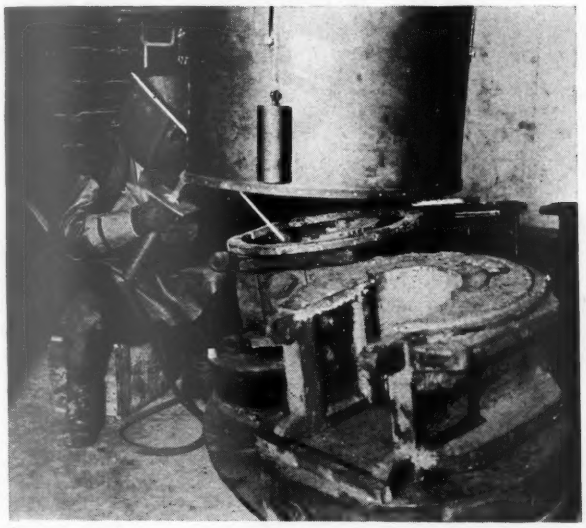
RAILWAY MECHANICAL ENGINEER

Founded in 1832 as the American Rail-Road Journal

With which are also incorporated the National Car Builder, American Engineer and Railroad Journal, Railway Master Mechanic, and Boiler Maker and Plate Fabricator. Name Registered, U. S. Patent Office.

March, 1938

Volume 112 *No. 3*



See page 102

Published on the second day of each month by

Simmons-Boardman Publishing Corporation

1309 Noble street, Philadelphia, Pa. Editorial and Executive Offices: 30 Church street, New York, and 105 West Adams street, Chicago. Branch offices: Terminal Tower, Cleveland; 1081 National Press bldg., Washington, D. C.; 1038 Henry bldg., Seattle, Wash.; Room 1001, 485 California street, San Francisco, Calif.; Union Bank bldg., Los Angeles, Calif.

SAMUEL O. DUNN, *Chairman of Board; Chicago;* HENRY LEE, *President, New York;* LUCIUS B. SHERMAN, *Vice-Pres., Chicago;* ROY V. WRIGHT, *Vice-Pres. and Sec., New York;* FREDERICK H. THOMPSON, *Vice-Pres., Cleveland;* ELMER T. HOWSON, *Vice-Pres., Chicago;* FREDERICK C. KOCH, *Vice-Pres., New York;* ROBERT E. THAYER, *Vice-Pres., New York;* H. A. MORRISON, *Vice-Pres., Chicago;* JOHN T. DEMOTT, *Treas. and Asst. Sec., New York.*

Roy V. Wright
Editor, New York

C. B. Peck
Managing Editor, New York

E. L. Woodward
Western Editor, Chicago

H. C. Wilcox
Associate Editor, New York

W. J. Hargest
Associate Editor, New York

Robert E. Thayer
Vice-Pres. and Business Manager, New York

Subscriptions (including, when published, the daily editions of the Railway Age, published in connection with the convention of the Association of American Railroads, Mechanical Division), payable in advance and postage free, United States, U. S. possessions and Canada: 1 year, $3; 2 years, $5. Foreign countries, not including daily editions of the Railway Age: 1 year, $4; 2 years, $7. Single copies, 35 cents. Address H. E. McCandless, circulation manager, 30 Church street, New York.

The Railway Mechanical Engineer is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. B. C.), and is indexed by the Industrial Arts Index and also by the Engineering Index Service.

Locomotives:

General:

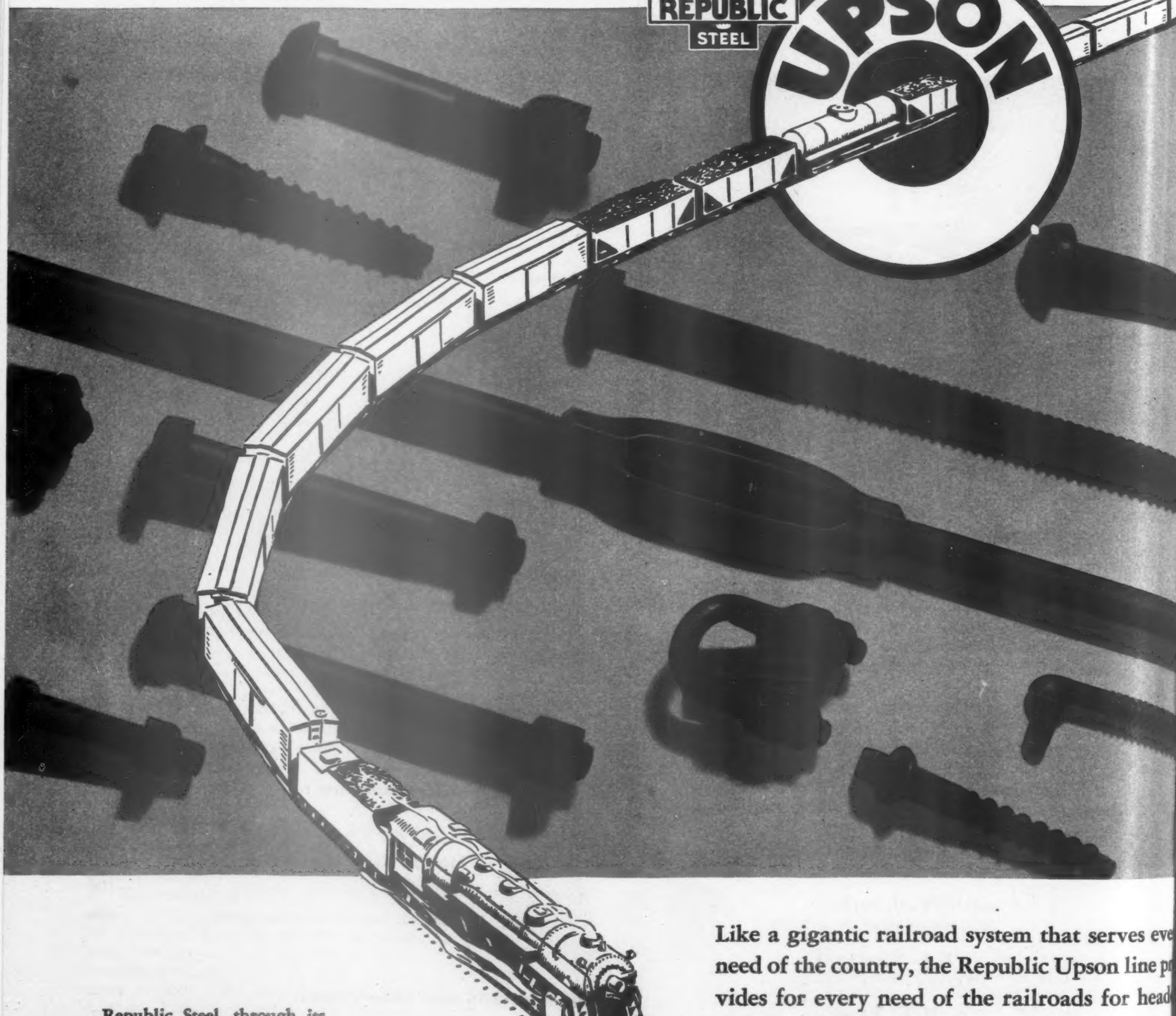
Editorials:

Back Shop and Enginehouse:

Car Foremen and Inspectors:

The line that has everything

Reg. U.S. Pat. Off.
REPUBLIC STEEL
UPSON



Like a gigantic railroad system that serves eve
need of the country, the Republic Upson line pr
vides for every need of the railroads for head
and threaded products.

A complete line of machine, carriage and l
bolts, nuts, rivets, pins, track bolts and spikes, tur
buckles, wire rope clips, and other items...a high uniformity in streng
accuracy and finish...an unsurpassed record for performance that covers
years...these are but three of the reasons why you should consider the pos
bilities of Republic Upson Quality Products. For complete informatio
write Republic Steel Corporation, Bolt and Nut Division, Cleveland, Oh

Republic Steel, through its fine carbon and alloy steels, sheets, pipe and countless other products, including ELECTRUNITE Boiler Tubes, of Steel and Tubes, Inc., Truscon Weltrus Crossings and Berger sheet metal products, is one of the largest suppliers of railroad products in the world.

Republic Steel

BERGER MANUFACTURING DIVISION
NILES STEEL PRODUCTS DIVISION
UNION DRAWN STEEL DIVISION
TRUSCON STEEL COMPANY
STEEL AND TUBES, INC.

RAILWAY
MECHANICAL ENGINEER

A Study, Based on Laboratory Results, of

The Locomotive Front End

Part III*

By H. S. Vincent

An investigation of the laws which govern the flow of steam and gas in a locomotive front end—The author discusses the feasibility of reducing back pressure in locomotive cylinders

Area of Nozzle

THE area of the nozzle for any combination of steam flow and back pressure may be determined by a transposition of equations (6) and (7), in which

$$A_2 = \frac{M_o V_2 \sqrt{Z}}{223.7 \sqrt{\Delta H C}} = \frac{M_o V_2}{W} \qquad (23)$$

In Fig. 24 is shown the relation between M_o and A_2 for various increments of ΔP as derived from the curves shown in Figs. 5 to 12, inclusive. Within range of the tests cited, it is apparent that the steam flow for any value of ΔP increases in approximately a straight-line relation to the nozzle area, independently of the type of nozzle employed. Young [1**] found that this true for nozzles of similar form.

In column 8 of Table VII is given the steam flow per second per pound of ΔP for a constant value at $\Delta P = 10$ as derived from the curves in Figs. 5 to 12, inclusive, while in column 14 is given the flow as estimated from the equation in Fig. 24 applying to $\Delta P = 10$, in which

$$M_o = 3.75 + (35.1\ A_2)$$

It will be observed from column 15 of Table VII that the calculated flow in no case varies more than 4.1 per cent from the actual flow, and in most instances the variation is much less. This exhibit would seem to prove the statement that, within the range of the tests being considered, the steam flow for any given value of ΔP is a straight-line function of the nozzle area.

Reducing Back Pressure

In present locomotive practice, the area of the exhaust nozzle is based on a certain proportion of the tube and flue area, or in some cases on the cylinder area or volume. These empirical rules have been established from long experience, and the resulting operation is more or less satisfactory.

The Master Mechanics front-end arrangement, using a circular nozzle, is in almost universal use for coal-burning locomotives in the Americas. With this combination, and in fact with any other arrangement, once the correct area of the nozzle has been established, it cannot be changed without affecting the steaming capacity of the locomotive or varying the cylinder horsepower output.

It has been shown in Fig. 22 that, by a change in the type of nozzle and in the front-end arrangement of a locomotive, considerable improvement can be effected in steaming capacity without a corresponding drop in cylinder power. This is brought about by better entrainment of the gases and by a reduction in the resistance to gas flow, without seriously affecting the self-cleaning function of a front-end apparatus.

By taking, for example, locomotive A which is equipped with a modern and efficient type of nozzle and

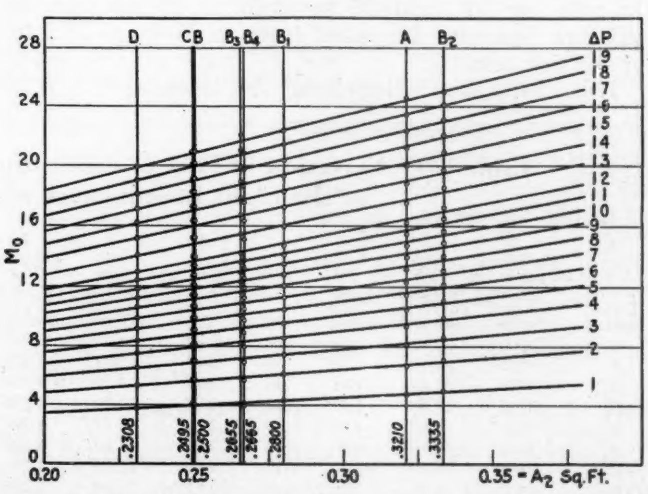


Fig. 24—Relation between steam flow M_o and nozzle area A_2 for various increments of ΔP

Value of ΔP	Equation	Value of ΔP	Equation	Value of ΔP	Equation
1	1.18 + 11.11	8	3.24 + 31.79	15	5.94 + 44.30
2	1.60 + 16.00	9	3.55 + 33.30	16	6.24 + 46.92
3	2.06 + 19.24	10	3.75 + 35.12	17	7.12 + 47.40
4	2.30 + 22.52	11	3.98 + 36.66	18	7.55 + 49.55
5	2.44 + 25.45	12	4.05 + 38.75	19	8.15 + 50.70
6	2.76 + 27.69	13	4.65 + 40.70		
7	3.11 + 29.45	14	5.49 + 42.00		

(To find M_o at $\Delta P = 10$: $M_o = 3.75 + (35.12\ A_2)$)

front-end arrangement, it will be shown what is involved in attempting a further reduction in back pressure in this locomotive. It will be seen from Figs. 5 and 5C that with the existing apparatus the weight of gas moved per second over the heating surfaces is $W_g = 38.75$ lb., requiring a steam flow M_o of 20 lb. per sec. through the nozzle; this necessitates a back-pressure equivalent of $\Delta P = 15$. It will now be assumed that

* Parts I and II of this article were published in the January and February issues, respectively.
** Footnotes 1 to 5, inclusive, were published with Parts I and II of this article.

ΔP is reduced to 12, using the quantities shown in Table V for this pressure. From equation (23)

$$A_2 = \frac{20 \times 29.14 \times \sqrt{Z}}{223.7 \times 7.119 \times C}$$

If we assume no change in A_1 from that given in column 3 of Table IV for locomotive A, then

$$Z = 1 - \left(\frac{18.41}{29.14}\right)^2 \left(\frac{A_2}{0.959}\right)^2$$

and from equation (12) $C = 1.1075 - 0.606\ A_2$; however, both Z and C require A_2 for their solution. From Fig. 24 we obtain the approximate value of A_2 by the equation

$$A_2 = \frac{20 - 4.05}{38.75} = 0.41 \text{ sq. ft.}$$

Then $Z = 1 - (0.398 \times 0.1826) = 0.9274$, and $C = 1.1075 - (0.606 \times 0.41) = 0.859$. Therefore

$$A_2 = \frac{20 \times 29.14 \times \sqrt{0.9274}}{223.7 \times 7.119 \times 0.859} = 0.41 \text{ sq. ft.}$$

which checks the approximate value of A_2 as found from Fig. 24.

It has been shown by Fig. 22 that for any type of nozzle $W_g \propto \sqrt[3]{A_2}$; therefore the gas flow for a nozzle having an area of 0.41 sq. ft. is

$$W_g = \frac{32.75 \times \sqrt[3]{0.41}}{\sqrt[3]{0.321}} = 35.5 \text{ lb.}$$

In reducing ΔP from 15 to 12 lb. or 20 per cent, the gas flow has been decreased from 38.75 lb. to 35.5 lb., or 8.3 per cent.

It has been shown elsewhere[6] that locomotive A, when working at the rating assumed in the example, transfers about 60 per cent of the available heat through the tubes and superheater. Therefore, the loss in evaporation is 0.6 x 8.3 = 4.98 per cent. Since approximately 13 per cent of the heat transferred in the boiler is converted into work in the cylinder, the loss in cylinder power is also 4.98 per cent.

The reduction of 1 lb. in back pressure adds from 0.5 to 2 per cent to cylinder horsepower, depending on the cutoff. For an assumed cutoff of 50 per cent, the reduction of 3 lb. in the value of ΔP, as assumed in the foregoing example, represents a gain of 3 per cent in cylinder work. Therefore, the net loss is 4.98 — 3 = 1.98 per cent. Any further reduction in the value of ΔP would result in a greater cylinder loss, so there is apparently nothing to be gained in this case by simply enlarging the nozzle.

A reduction in back pressure without involving loss in cylinder output can be effected only by a further improvement either in the contour of the nozzle or in the design of the drafting apparatus to reduce gas resistance, or in both.

It has been shown in Fig. 20 that, in the model test, an increased air movement was effected by the application of a four-hole pepper-box nozzle in conjunction with a gyratory spark arrestor, over that obtained with a 1½-in. circular nozzle and Master Mechanics standard smokebox arrangement. It is reasonable to assume that the same percentage of increase could be maintained in the actual locomotive.

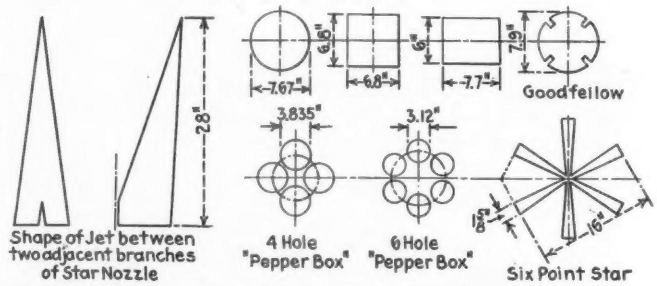


Fig. 25—Right: Relation between area and perimeter of various forms of locomotive exhaust nozzles, all having equal area. Left: Development of jet between two branches of the six-point star nozzle

It is shown in Fig. 22 that with a Goodfellow nozzle having an area of 0.321 sq. ft., in conjunction with a Master Mechanics front-end arrangement, locomotive A will move 28.8 lb. of gas per sec. when $\Delta P = 14$. If this locomotive were equipped with a four-hole pepper-box nozzle of the same area, operated in combination with a GB gyratory spark arrestor, the gas moved would be 28.8 x 1.276 = 36.75 lb. per sec. The six-point star nozzle and type of drafting apparatus shown in Fig. 1 for the locomotive A moves 37 lb. of gas per sec. using the same values of ΔP and M_o assumed in the foregoing example. Therefore, both arrangements show about equal efficiency.

In Table VIII is shown the cylinder loss or gain incurred by increasing the area of the nozzle of locomotive A, but without changing the steam flow. It will be seen that for any increase in the nozzle area above 0.34 sq. ft. a cylinder loss is involved. At a nozzle area of 0.338 sq. ft. there is a small gain in the cylinder output. The indication from this exhibit is that the nozzle of loco-

Table VII—Variation in Fuel Consumption, Gas and Steam Flow in Actual Operation of the Eight Locomotives when ΔP Remains Constant at 10

1 Locomotive	2 Fuel fired, lb. per sq. ft. grate surface per hr.	3 Gas flow through boiler, lb. per sec.	4 Lb. of gas per lb. of steam, C_s	5 ΔP	6 P_1	7 Steam flow at ΔP, lb. per sec.	8 Steam flow per lb. of ΔP, lb. per sec.	9 Gas flow per lb. of ΔP, lb. per sec.	10[a] Gas flow, per cent	11[a] Steam flow, per cent	12[b] Col. 8/ (nozzle area), lb.	13[a] Percentage of col. 12	14[c] Steam flow per lb. of ΔP, lb. per sec.	15 (Col. 14 — col.) ÷ col. 8
A	139.0	30.15	2.04	10	24.7	14.77	1.477	3.015	136.5	115.5	0.0460	90.0	1.501	+1.5
B	90.2	22.10	1.73	10	24.7	12.78	1.278	2.210	100.0	100.0	0.0511	100.0	1.252	−2.1
B_1	98.0	25.80	1.91	10	24.7	13.50	1.350	2.580	117.0	105.6	0.0482	94.2	1.358	+0.6
B_2	118.0	28.57	1.82	10	24.7	15.70	1.570	2.875	129.3	122.9	0.0481	94.0	1.546	−1.5
B_3	90.0	20.20	1.56	10	24.7	12.97	1.297	2.020	91.4	101.5	0.0489	95.7	1.307	+0.8
B_4	97.0	20.15	1.60	10	24.7	12.60	1.260	2.015	91.2	98.5	0.0473	92.6	1.311	+4.1
C	119.8	22.25	1.74	10	24.7	12.78	1.278	2.225	100.7	100.0	0.0512	100.2	1.251	−2.2
D	83.0	24.35	2.05	10	24.7	11.86	1.186	2.435	110.2	92.8	0.0514	100.6	1.185	−0.1

Note: [a] Basis = 100 per cent. [b] Nozzle area, sq. in. [c] Estimated from Fig. 24.

[6] "Heat Transmission in Locomotive Boilers," by H. S. Vincent, *Railway Mechanical Engineer*, vol. 109, May, June and August, 1935, pages 180, 228 and 335, respectively. Refer to locomotive M1a.

motive A could be increased with advantage from its present area of 0.321 sq. ft. to 0.34 sq. ft.

It has been shown that little can be accomplished in facilitating the movement of combustion gases by a mere change in the nozzle area, any improvement in the gas movement being accompanied by a corresponding increase in the exhaust pressure. It is also evident that by a change in the nozzle contour a considerable improvement in front-end operation can be secured.

Table VIII—Effect of Increasing Nozzle Area, with Constant Steam Flow, for Locomotive A

M_e, lb.	A_2, sq. ft.	V_2, cu. ft.	$\sqrt{\Delta H}$, lb.	Z	C	ΔP	W_g	Loss in steaming capacity of boiler per cent	Net cylinder loss or gain, per cent
20	0.321	23.91	7.214	0.955	0.903	15.0	38.75	...	...
20	0.347	25.41	7.175	0.949	0.890	14.0	38.00	1.16	0.16 loss
20	0.367	26.55	7.156	0.942	0.876	13.5	37.60	1.78	0.28 loss
20	0.373	27.07	7.138	0.939	0.872	13.05	36.90	2.88	0.88 loss
20	0.410	29.14	7.119	0.927	0.858	12.0	35.52	4.98	1.98 loss
20	0.338	24.78	7.17	0.951	0.891	14.4	38.40	0.54	0.06 gain
21	0.321	....	....	....	....	15.5	39.50	...	...
21	0.340	....	....	....	....	15.0	39.50	...	...

Note: For definition of terms in column headings and their units, see Table III.

In Fig. 25 is shown diagrammatically the various shapes of nozzles here discussed, all having the same area; the essential dimensions and ratios are given in Table IX. There is evidently an important relation between the weight of gas moved in unit time and the ratio between the area and the perimeter of the jet. This ratio is least for the circular nozzle and greatest for the six-point-star type, the ratio for the latter being four times that of the circular nozzle. The second best ratio is given by the six-hole pepper box nozzle.

It cannot be assumed that the relative gas movement will be proportional to the perimeter-area ratio of the nozzle, since the relative ratios of the resulting jets may be quite different from that of the nozzles. It may be said that the more nearly any form of jet approaches the circular, the less efficient it will be. For this reason the six-hole pepper-box nozzle has been found less efficient than the four-hole type.

It would be possible, for example, to scallop the edge of the circular nozzle, thus obtaining a better perimeter ratio, but the resulting jet at a point a few inches above the nozzle would return to the circular form. We may then with reason conclude that the nozzle whose shape is such that it effects the deepest convolutions in the jet is the most efficient. Of the nozzles shown in Fig. 25, the six-point star has the largest perimeter ratio and is of such contour that the resulting jet retains its original shape for a considerable portion of its traverse between the nozzle and the stack, thereby offering the maximum surface area for entrainment of the gases.

Table IX—Geometrical Relations of Various Shaped Nozzles, All Having Equal Area

	Area sq. in.	Perimeter, in.	$\frac{\text{Perim.}}{\text{Area}}$	Mean hydraulic radius	Diam., in.
Plain circular	46.2	24.1	0.521	1.920	7.670
Square, 6.8 in.	46.2	27.2	0.588	1.700	....
Rectangle, 6 x 7.7 in.	46.2	27.4	0.593	1.685	....
Four-hole pepper box..	46.2	48.2	1.043	0.958	3.835
Six-hole pepper box...	46.2	58.8	1.273	0.785	3.120
Goodfellow	46.2	36.3	0.786	1.270	7.900
Six-point star	46.2	100.0	2.166	0.462	....

Also shown in Fig. 25 is the shape of the jet between two adjacent branches of the six-point nozzle, assuming a jet flare of 7 deg. It will be seen that the jet forms a tent-like convolution extending from 3 in. at the center to about 28 in. at the periphery above the nozzle, or at the meeting point of the steam from the two adjacent openings. It has been shown that the jet from the star nozzle still retains its rococo shape when it comes into contact with the stack.

In the conventional type of locomotive, with any given design of nozzle or front end, a reduction in ΔP is gained at the expense of a corresponding loss in steaming capacity.

There are in operation a number of locomotives in which the maximum cutoff is limited to a smaller proportion of the cylinder stroke than obtains in the normal locomotive. For instance, locomotive C has a maximum cutoff of 55 per cent of the stroke, and it is perfectly feasible to operate a locomotive at a maximum cutoff as low as 30 per cent. In such a locomotive, the economy in the use of steam, especially at the lower speeds, is such that boiler capacity may be reduced correspondingly.

In a locomotive with limited cutoff it is more important to reduce back pressure to the minimum than it is in a normal locomotive, since the back pressure bears a larger ratio to the mean effective pressure. In Fig. 26 is shown a typical indicator card from a locomotive having a maximum cutoff of 30 per cent. The back pressure is given as 7 lb., allowing a drop of 1 lb. between the cylinders and point A_1 of the cylinder exhaust passage, making $\Delta P = 6$. It is further assumed that the boiler, smokebox arrangement and nozzle are similar to those of locomotive A.

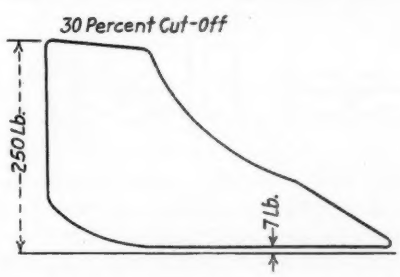


Fig. 26—Theoretical indicator card from locomotive with 30 per cent maximum cutoff

The problem is to determine the maximum weight of fuel which can be fired in unit time with the facilities available for moving the gases of combustion. It has been shown elsewhere [5] that the boiler efficiency of locomotive A is

$$F = 0.66 - 0.0876G \qquad (24)$$

and the gas generated per pound of fuel fired is

$$W_f = (18 - 0.014G)\ (0.84 - 0.001047G) \qquad (25)$$

It will be further assumed that $K = 13{,}500$ B.t.u per lb. Locomotive A is equipped with a type E superheater, a feedwater heater and carries a working pressure of 250 lb. per sq. in. Therefore, the heat supplied to the steam from the fuel $H_3 = 1{,}192$ B.t.u. per lb.

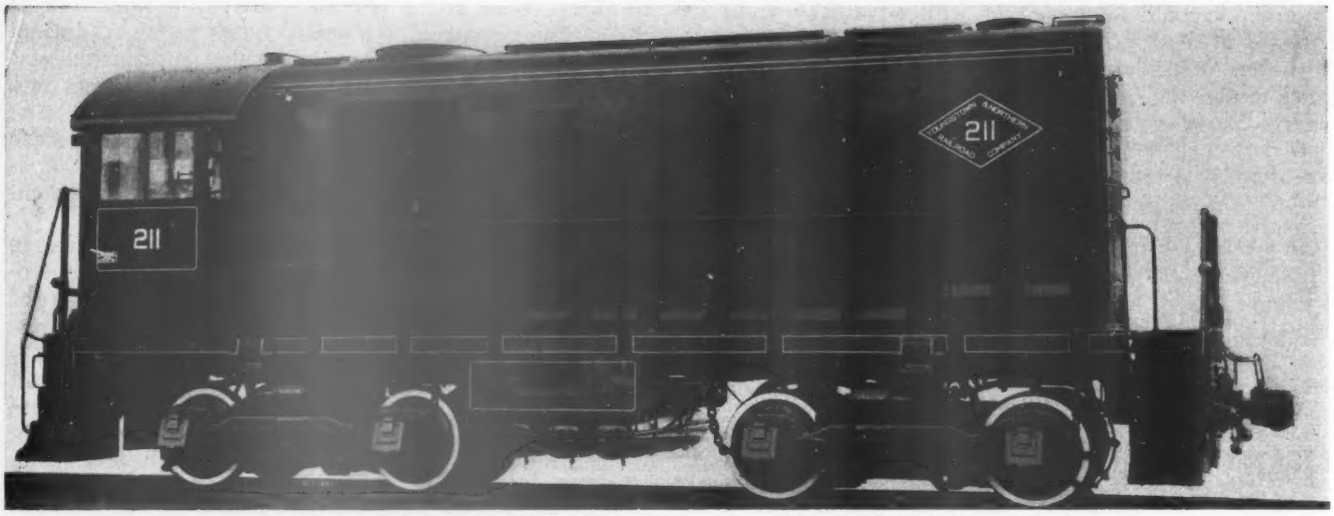
From Fig. 24 it will be found that the equation for A_2, when $\Delta P = 6$, is

$$A_2 = \frac{M_e - 2.76}{27.69} \qquad (26)$$

and from Fig. 22 it will be seen that for locomotive A, at $\Delta P = 6$, the value of W_g is 24.10 lb. The steam diverted to the locomotive auxiliaries is approximately 7 per cent.

By this method it is necessary to assume a value for G, and by calculation prove its correctness. It will there-

(*Continued on page 97*)



Youngstown & Northern 900 hp. supercharged Diesel electric switcher

Youngstown & Northern 900 Hp.

Diesel Electric Switchers

Two 900 hp. units are designed with ample reserve capacity. The Diesel engines are of the Alco standard type, and are equipped with superchargers

In October, 1937, the American Locomotive Company delivered two Diesel switchers to the Youngstown & Northern for transfer and heavy switching service. Each of these units contains one 900 hp. supercharged Alco Diesel engine. These locomotives are similar in design to one which has been in service on the South Buffalo Railway and the five in operation on the Birmingham Southern.

Mechanical Equipment

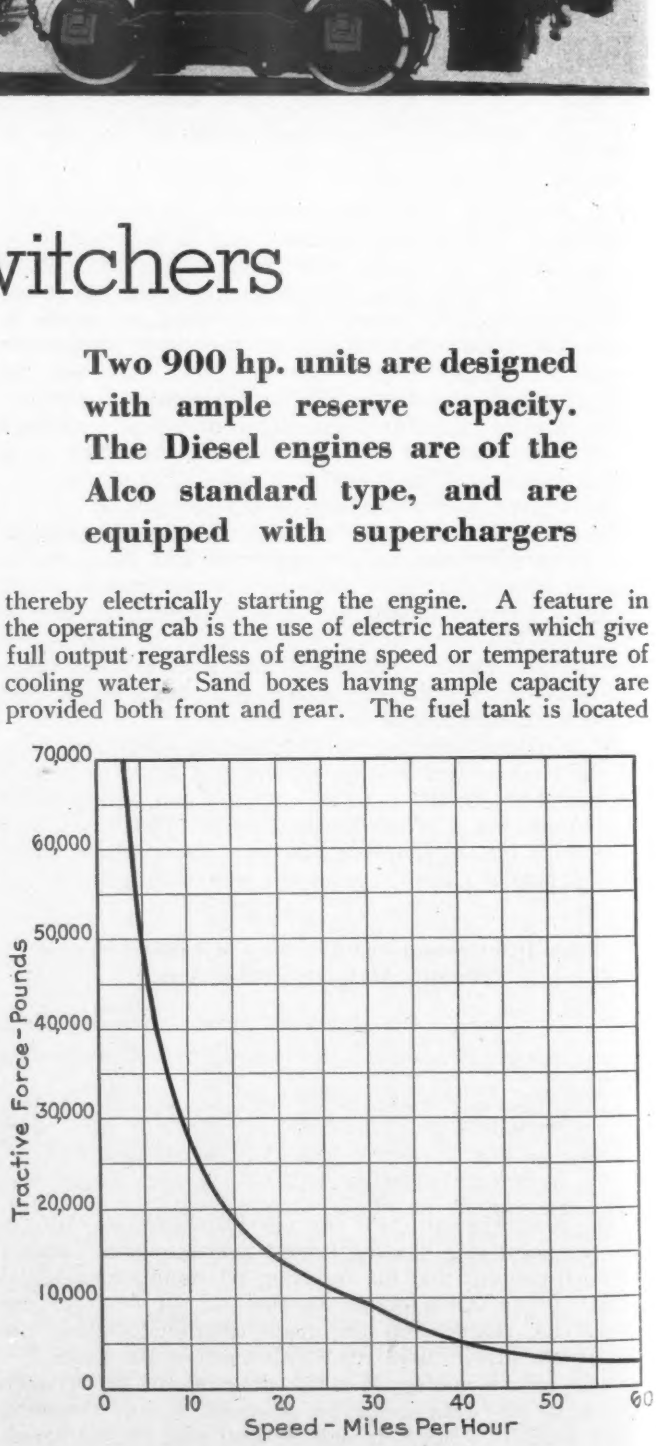
The operating cab is located at one end, while the hood construction is kept as narrow as possible, giving maximum visibility along the track. The underframe is constructed of heavy plate having the heavy center or backbone section especially designed for withstanding heavy shocks and collisions. The wide side steps on these locomotives are in accordance with standard practice on the steam switchers previously built by Alco for the Youngstown & Northern.

All operating details within the cab have been carefully laid out. The seats and arm rests are suitably upholstered. Side windows are suitably located for the engineman. The doors are of heavy steel plate. The control stand is conveniently arranged on the right side of the operator's cab.

The Diesel engine is started by pushing in a small button on the control stand which throws the current from a heavy-duty battery across the main generator, thereby electrically starting the engine. A feature in the operating cab is the use of electric heaters which give full output regardless of engine speed or temperature of cooling water. Sand boxes having ample capacity are provided both front and rear. The fuel tank is located

General Dimensions of the Youngstown & Northern Locomotives

Horsepower	900
Number of cylinders	6
Bore and stroke, in.	12½ x 13
Length overall, ft. and in.	43 - 11¾
Width overall, ft. and in.	10 - 0
Height from rail (max.), ft. and in.	14 - 9½
Wheel base, rigid, ft.	8 - 0
Wheel base, total ft. and in.	28 - 6
Truck Wheels, diameter, in.	40
Total weight locomotive, lb.	230,000
Weight on drivers, lb.	230,000
Starting tractive force, lb.	69,000
Cont. tractive force, lb.	30,000
Maximum speed, m.p.h.	60
Minimum radius curvature, locomotive alone, ft.	50



Tractive force—speed curve

underneath the operating cab and contains 500 gallons, which is ample for general operating conditions.

The power trucks, two in number, are of the four-wheel center-bearing type, having a special design of cast steel bolster. The axles are of open-hearth forged steel finished for truck and motor bearings, wheel and gear fits, and the journals are 8 in. by 14 in. The rolled-steel wheels are 40 in. in diameter. The brake rigging is all placed on the outside of the truck so that brake adjustments, inspection and brake-shoe renewals can be made with a minimum loss of time, and without going over a pit. The low side frames and absence of end frames allow ready accessibility to the inspection covers and oil reservoirs of the traction motors. The principal feature of this truck is that the construction provides for positive equalization at all times without the distortion of any truck members regardless of any uneven track condition.

Air-Brake Equipment

Two Westinghouse D-4-P air compressors are used to give a total of 100 cu. ft. per min. regardless of whether the Diesel engine is idling or operating at full speed. The air reservoirs are of exceptionally large capacity, containing 72,500 cu. in. Four air-brake cylinders, 12 in. by 10 in., are used. These cylinders are mounted on each side of each truck, taking care of equalization of braking entirely through air pipes. Automatic and straight-air brakes are used, operated through Schedule EL-14 equipment.

Electrical Equipment

These locomotives have ample reserve capacity. The four traction motors of the General Electric 726 type are especially suited to extra heavy duty service. The automatic control of the main generator is new though actually a modification of a proved design. It matches generator load to engine output at full engine speed through the entire range of locomotive speed. This feature eliminates the old differential control. The control was especially designed for the Alco 900-hp. Diesel locomotives. The generator is known as type GT-542.

An auxiliary generator delivering 125 volts at all engine speeds is used. This feature makes it possible to operate any one or all auxiliaries at full capacity at any time regardless of engine speed. The auxiliary generator, known as type GTB-542, is directly connected to the main generator which, in turn, is bolted to the Diesel engine, making the power plant one complete unit. The auxiliary generator furnishes current for the charging of the 56-cell heavy-duty starting battery, as well as the power to the air compressors, radiator fan motor, traction-motor blower motor, fuel booster pump and cab heaters.

The entire control of the locomotive is embodied in the operator's throttle which simply regulates the speed of the Diesel engine. Reversal is effected by a separate lever operating a master controller. The motors are operated in series at low speed and are automatically changed by a voltage relay to series parallel and again automatically changed to field shunt for high locomotive speeds.

Supercharged Diesel Engine

The Diesel engine used in these switchers is in effect the Alco standard six-cylinder 600-hp. engine supercharged to develop 900 hp. The bore and stroke is 12½ in. by 13 in. An interesting feature of this supercharged engine, as indicated by tests, is that it has no higher maximum pressures and actually lower exhaust temperatures than the same engine not supercharged. As far as the Diesel engine and supercharger are concerned these are the same as were used on the Birmingham Southern locomotives and were described in detail in the August, 1937, issue of *Railway Mechanical Engineer.*

Fundamentals Involved in

The Stopping of Trains*

By J. C. McCune†

A discussion of air-brake elements lying between the brake cylinder and the rail which limit or affect the retardation obtained when an application of the train brakes is made

In recent years, improvements in railroad practices have changed the underlying trend in air-brake development. It is no longer a matter of effecting changes so that the air-brake equipment *per se* will function more uniformly and satisfactorily, but of meeting requirements established by new demands for improved overall braking performance. To satisfy these demands, the entire braking system must be surveyed and the action of all elements co-ordinated so that the maximum efficiency may be obtained from the proper correlation of all the interdependent parts.

Specifically, this paper deals with those elements of the air-brake system which lie between the brake cylinder and the rail and which directly limit or affect the retardation obtained by an application of the brakes. These elements are the rail, the wheel, the brake shoes and the foundation brake rigging. Recent changes in railroad operating practices have emphasized the part these elements play in securing high rates of retardation. Without an understanding of the performance of these elements during braking action, and a realization of the limiting factors in obtaining improved performance, what can or can not be done with air brakes can not be clearly comprehended.

What stops a moving train when the brakes are applied? Essentially one thing, and that is the friction between the wheel and the rail. The amount of friction is determined by the resistance the wheel meets in its effort

* Abstract of a paper presented before the Southern and Southeastern Railway Club, at Atlanta, Ga., January 20, 1938.
† Mr. McCune is director of research of the Westinghouse Air Brake Company.

to revolve. Thus, when brake shoes under considerable pressure are applied to the wheels, the wheels revolve with difficulty and on this account, a very substantial friction exists between wheel and rail. This friction eventually arrests the motion of the train. Therefore, it is evident that the train is stopped, not directly by the brake-shoe friction, but by the very high friction the action of the brake shoes sets up between wheel and rail. This rail friction or retarding force is sometimes called adhesion, but in this paper, the designation "rail friction" will be employed. It should be kept in mind that, in discussing braking, rail friction is the same thing as retarding force.

Rail friction can attain high values before the wheel slides because it is static friction and not kinetic friction. Static friction is much greater than kinetic friction, especially when the velocities involved in kinetic friction are relatively great. From this it follows that all wheels under a train must continuously revolve if the stop is to be made in the shortest distance because then the rail friction or retarding force is greatest, since it is produced by static friction.

Although rail friction increases with the difficulty the wheel finds in revolving, it can not increase indefinitely. After the rail friction reaches a certain value, the wheel ceases to revolve and slides instead. The ratio of this limiting value to the weight on the rail is called the coefficient of adhesion. Thus, if the coefficient of adhesion is 25 per cent, the rail friction or retarding force can not exceed 25 per cent of the weight carried by the wheel. It should also be understood that this coefficient of adhesion must be applied to the wheel weight or pressure actually existing at the rail. This weight or pressure need not necessarily be the same with the car moving as with the car standing. For instance, during a stop, the car tends to overturn, with the result that weight is "transferred" from the trailing wheels to the leading wheels. Again, the wheel may oscillate due to the action of rail joints and for brief periods, the pressure on the rail may differ from the static weight. When the coefficient of adhesion is used to determine the maximum rail friction or retarding force, these variations from static wheel load must be kept in mind.

In braking trains, therefore, the coefficient of adhesion fixes the maximum retardation which can be employed. Stated in different words, it is the rail which limits the minimum stop distance, not the brake. It is obvious that if wheels are to revolve throughout the stop, the coefficient of adhesion must not be exceeded. It is advantageous in this connection to employ the term "per cent retardation" which may be defined as the ratio of the rail friction or retarding force to the weight actually carried by the wheels. This is the same ratio which is used to define the coefficient of adhesion but "per cent retardation" gives the ratio below the sliding point whereas the "coefficient of adhesion" gives the ratio at the sliding point. Thus, if the coefficient of adhesion is 25 per cent, any per cent retardation less than 25 could be used in braking a single car and there would be complete immunity from wheel sliding.

The Coefficient of Adhesion

Unfortunately, the coefficient of adhesion is by no means constant. Values for it have been reported by different experimenters ranging all the way from 8 per cent without sand on a poor rail to 40 per cent with sand on a good rail. For many years it has been considered in the air brake art that 25 per cent was attainable on the average rail, probably because this same value was employed in locomotive practice. Generally, the interest is in stop distances and not coefficients of adhesion, so that it seems worth while to examine what stop distances various coefficients of adhesion will permit.

The stop distance can be roughly determined when the retardation is known. This retardation is generally expressed in miles per hour per second. With 100 per cent retardation, the retarding force equals the weight carried by the wheel. A body decelerated by a retarding force equal to its own weight receives a retardation of 32.2 ft. per sec. per sec. But 32.2 ft. per sec. per sec. equals approximately 22 m. p. h. per sec. Thus, 100 per cent retardation means a retardation of 22 m. p. h. per sec. If 22 is multiplied by the per cent retardation expressed as a decimal, the result is the retardation in miles per hour per second.

From the foregoing, it is possible to calculate the stopping distances from 100 m. p. h. for different per cent retardations, such as given in the following table:

Retardation per cent	Retardation m.p.h. per sec.	Stops from 100 m.p.h. must exceed
10	2.2	3,333 ft.
15	3.3	2,222 ft.
20	4.4	1,666 ft.
25	5.5	1,333 ft.
30	6.6	1,111 ft.

It will be noted that it is said that the stopping distances must exceed the values given in the table. This is because the stopping distances are calculated on the assumption that the per cent retardation is instantaneously developed, is constant throughout the stop, and has the same value on every axle in the train. As none of these assumptions exist in actual practice, actual stops must always exceed these limiting stops and generally do so by a very substantial amount.

A sudden change of weather may necessitate a decreased brake effectiveness or longer stops. In the case of the rail, the conditions which prevail the greater part of the time provide a coefficient of adhesion of from, say, 20 to 25 per cent, which if *all other circumstances were ideal,* would permit a retardation of from 4.4 to 5.5 m. p. h. per sec. and a stop from 100 m. p. h. in from 1,333 to 1,666 ft. The more the braking system is improved, the nearer these ideal conditions will be approached.

The present era is one of speed and both passenger and freight trains are operating with higher schedule speeds than ever before. As a consequence, the stopping of these trains assumes a greater importance than it had in the recent past because of the higher speeds involved; therefore, to obtain short stops, it is necessary to apply a greater retarding force earlier in the stop. But this means that the danger of sliding wheels at the higher speeds is increased. The air brake must depend upon a high coefficient of adhesion or a good rail in order to obtain short stops, but if the rail happens to be poor, wheel sliding will result if an attempt is made to make these short stops. Up to date, the practice in the brake art has been to accept these occasional slides as the price of obtaining good stops under average conditions, but the rapid change in railroad operating methods may before long make this practice unacceptable.

Empty-and-Load Brakes

Much has been said by way of emphasizing that the rail determines the minimum length of stop. But the rail as the limiting factor has resulted in the development of a special air-brake equipment, namely, the empty-and-load brake. In the conventional single-capacity brake, the brake-shoe pressure in an emergency application is the same for the empty car as for the loaded car. Likewise the rail friction or retarding force does not change when the car is loaded. But it is clear that the retarding force per ton of weight to be braked does change radi-

cally. For instance, if the gross to tare ratio is 4 to 1, the empty car has four times the retarding force per ton that exists on the loaded car.

The necessity for empty-and-load brakes did not arise from any limitation within the air-actuated mechanism itself, but came instead because either rail adhesion or slack control prevented the use of one piston to operate the brakes on both the empty and the loaded car.

Practically, the need for empty-and-load brakes is less, the lower the gross to tare ratio. However, three factors have increased the gross to tare ratio for trains as a whole in recent years. First, the introduction of light-weight cars with a high gross to tare ratio; second, the withdrawal from service of older cars with a low gross to tare ratio; and, third, the intensive efforts to increase the average revenue load per car. All of these factors have reduced the effectiveness of the conventional single-capacity brake on loaded freight trains. However, the need for effectiveness has increased because loaded freight trains are now operated at speeds markedly higher than in the very recent past. The existence of these conditions amply justifies the Association of American Railroads in its recent action in specifying a minimum load braking ratio for new cars.

The Coefficient of Brake-Shoe Friction

It is generally recognized that a moving train represents a tremendous amount of kinetic energy, but it is difficult to visualize this energy so that it has a definite meaning. Perhaps, it can be better comprehended if the rate of doing braking work is expressed in terms of horsepower. When a brake dissipates 550 ft.-lb. of mechanical energy per sec. into heat, the brake is said to be dissipating 1 hp. It can be shown that the horsepower dissipated per ton, is the product of the retardation in m. p. h. per sec. and the speed in m. p. h. divided by 4.11. If a conventional axle with 30,000-lb. load were retarded at 4 m. p. h. per sec. 1,095 hp. would be dissipated at 75 m. p. h. It should, of course, be kept in mind that the instantaneous horsepower being dissipated decreases with the speed and becomes zero when the speed is zero.

Cast iron, for railroad service, appears the material best adapted to dissipating large quantities of heat and at the same time producing maximum friction with minimum wear. The brake-shoe friction is an actual force and is measured in pounds. However, it is more convenient ordinarily to refer, not to the friction itself, but to the ratio it bears to the pressure which produces it; that is, the coefficient of friction f which may be expressed either as a decimal or as a per cent. For illustration, if the coefficient of friction f is 10 per cent, the brake-shoe friction is 10 per cent of the pressure with which the brake shoe is pressed against the wheel.

From a braking viewpoint, it is highly desirable that f having a constant value, because the coefficient of adhesion, for a given rail condition, is the same at all speeds or at least does not appear to change to any marked extent. Therefore, the retarding force or rail friction, in emergency applications where short stops are desired, should remain constant. Since the rail friction is established by the brake-shoe friction, the brake-shoe friction should likewise be constant. The emergency cylinder pressure in the conventional brake is constant; therefore, the brake-shoe pressure is constant. If the ratio of friction to pressure or f did not change, obviously the retarding force would not vary. But unfortunately f does vary and in a manner poorly adapted to the requirements of the brake. This is because f decreases as the speed increases for all normal conditions where the heat dissipated is within the thermal capacity of the shoe. Consequently, for a constant cylinder pressure, the least retardation is secured at the higher speeds and the most at the lower speeds. To obtain short stops, the brake should be, if anything, most effective at the highest speeds because then so much distance is being rapidly covered. Since the reverse is true with cast-iron shoes, cast iron is not the ideal material for a brake shoe. How this has affected the development of brakes for high-speed trains will be mentioned later.

Not only does f decrease as the speed increases, but it also decreases as the pressure increases. When the brake-shoe pressure is increased, therefore, the friction obtained does not increase in the same proportion. Thus, if the pressure on the brake shoe is doubled, the friction is by no means doubled. The coefficient of friction for low shoe pressures is considerably greater than for high shoe pressures, the speed remaining constant. On this account, when a great deal of friction is wanted, it is obtained with difficulty, because the shoe pressure would have to increase, even if the coefficient of friction remained constant; as the coefficient actually decreases, a still further increase in pressure is called for.

It should be understood that f for a given speed and pressure does not always possess precisely the same value. This can be readily understood when it is considered that the friction is caused by intimate contact between shoe and wheel. The contact surfaces of both the shoe and the wheel change and as a result, f is not always the same for a given speed and pressure. This same variation in f, for what are apparently the same conditions, is found with all rubbing surfaces.

The Foundation Brake Rigging

The foundation brake rigging transmits and multiplies the force delivered by the brake cylinder in order to develop pressure on the brake shoes. Modern practice is to apply a brake-shoe pressure to the wheel which, nominally, is some two to three times the weight carried by the wheel. If a truck carried a load of 20 tons, this would mean nominal brake-shoe pressures of 40 to 60 tons; therefore, the parts of the brake rigging must be of large section and great strength.

It is obvious that these forces can not be transmitted with 100 per cent efficiency and that the actual pressure on the brake shoes is less than that indicated by multiplying the pressure on the brake piston by the leverage ratio. The ratio of the actual brake-shoe pressure to that which would be obtained if all the indicated pressure reached the brake shoes is called the rigging efficiency and for many years has been designated by e.

This matter of rigging efficiency is becoming of increasing importance because brake forces have been increased to meet the requirements of higher schedule speeds. The brake cylinder itself does not deliver all the force the piston receives from the pressure of the compressed air because of packing cup friction and resistance of the release spring. Perhaps 95 per cent would fairly measure the efficiency of the average cylinder. Then the efficiency of the pins, because of friction, is less than 100 per cent and decreases as the diameter of the pin increases.

The efficiency is further reduced because, with modern car construction and the increase in accessory equipment, it becomes increasingly impossible to employ the long rods, levers and hangers which provide the highest efficiency. It is not always recognized that friction reduces the efficiency of a short rod more than it does the efficiency of a long rod. Rubbing, binding, interferences of various sorts, and external release springs, obviously lower the rigging efficiency. In addition, the efficiency is further cut down by the angularity of various mem-

bers of the brake rigging. As a result of all these factors, the efficiency of the rigging is materially less than 100 per cent. About 25 years ago, the standing rigging efficiency of passenger clasp brakes was measured, in a few experiments, at from 60 to 85 per cent.

These experiments measured the efficiency between the brake cylinder and the brake beam. But the brake beam pressure is not directed toward the center of the wheel and it is this direct radial pressure which determines the amount of brake-shoe friction obtained. The determination of the direct radial pressure with the wheel revolving becomes a matter of considerable difficulty but generally the effect is to reduce the rigging efficiency further. Consequently, it appears that brake riggings are inherently not as efficient as generally they are considered to be.

It has long been the practice in the air-brake art to increase the force delivered by the brake cylinder so as to obtain the desired pressure on the brake shoes, irrespective of the rigging efficiency. It is becoming increasingly difficult to follow this practice in modern high-speed passenger braking because of the effect of these high forces upon the truck springs and the functioning of the truck. It is clear that the higher the rigging efficiency, the lower the braking forces transmitted from the brake cylinder need to be. On this account, very careful consideration of the brake rigging is justified.

Braking Ratio

Braking ratio expresses the ratio of the force on the brake-cylinder piston, multiplied by the leverage ratio of the rigging, to the weight being braked. What has been said about the efficiency of the brake rigging makes it evident that braking ratio is frequently employed in an improper sense.

Very generally it is thought that if two cars have the same braking ratio, they will be retarded at the same rate or will stop in the same distance from a given speed. This is not necessarily true. Braking ratio gives the pressure of the brake shoes, assuming 100 per cent efficiency, as a percentage of the weight being braked. But the efficiency is not 100 per cent and never has been. Because the efficiency of the brake rigging is not the same on all cars, the braking ratio should be multiplied by the rigging efficiency to obtain the actual pressure of the brake shoes on the wheels as a percentage of the weight braked.

Even the actual pressure of the brake shoes does not give the complete story. The coefficient of friction is not necessarily the same on all cars, if for no other reason than the difference in wheel loads and consequently in brake shoe loads, (since it has been pointed out that the coefficient changes with shoe load). Since the retarding force is the force to be considered and since this force is equal to the brake-shoe friction, recognition must be given to the friction actually obtained from a certain shoe pressure. But this is done by multiplying the actual shoe pressure by the coefficient of friction. Therefore, the braking ratio multiplied by the rigging efficiency and then by the coefficient of friction, gives a product which is the retarding force expressed as a percentage of the weight braked.

But this percentage has previously been defined as the "per cent retardation". If the possibilities of wheel sliding, the uniformity of braking on all axles, the rates of retardation and stop distances to be expected, and other questions of this character are to be examined, then knowledge of the per cent retardation is necessary. From all of this, it is evident that when entirely new conditions are confronted, braking ratio alone is not a sufficient indicator of what may be expected.

The Wheel

Under modern conditions, the wheel has been called upon to perform increased duty because, in many cases, not only has the load on the wheel been augmented, but also there has been a marked increase in the speed of operation. Much of the heat generated at the rubbing surfaces between brake shoes and wheels is lost by radiation. Since the speed is highest when the maximum heat is generated, the loss of heat to cooling currents of air is quite appreciable. Furthermore, a substantial amount of heat is carried away by the brake shoe dust, since the dust is heated to incandescence and forms sparks. Clearly the heat so obviously carried away by sparks does not pass into either the brake shoe or the wheel. However, it should be mentioned that the length of time the brake acts has a great deal to do with how much heat penetrates the wheel.

High-Speed Passenger Braking

Within the past few years, the schedule speed of passenger trains has been increased. In many cases, this has involved an increase in the maximum speed permitted. Emergency stopping distances vary with the square of the speed, all other conditions remaining the same, and assuming that (1) the brake reaches full effectiveness instantaneously and (2) the retarding force is constant throughout the stop; thus when the speed is doubled the stop distance increases four times.

In actual practice, the full effectiveness of the brake is not instantaneously developed and neither is the retarding force constant nor uniform throughout the stop. The air-brake equipment produces maximum cylinder pressure in a certain time which does not change with the speed of the train. This time becomes longer, moreover, as the number of cars in the train increase, and frequently an increase in train length has accompanied an increased schedule speed. On this account, stops from higher speeds tend to lengthen out of proportion, because of the time required to apply the brakes fully.

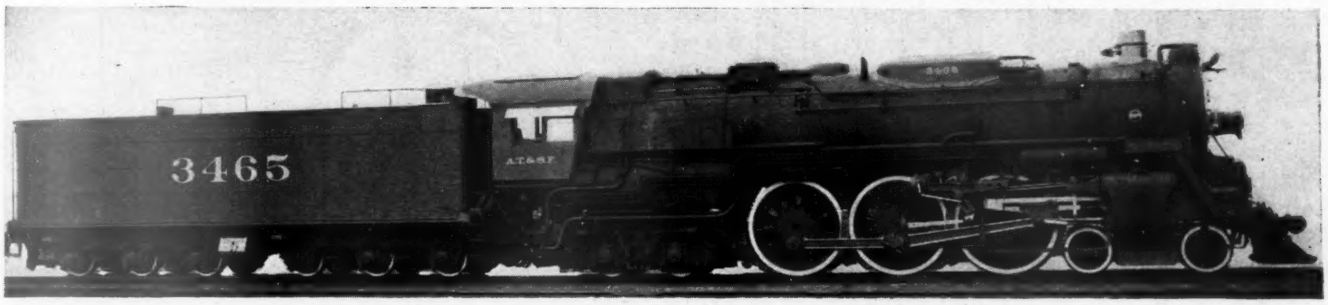
With conventional air-brake equipment, it has long been the practice to develop a certain pressure in the brake cylinder with an emergency application and to hold this pressure unchanged throughout an emergency stop. Evidently this means that the shoe pressure is substantially uniform throughout the stop. If the coefficient of friction did not change, a constant brake-shoe friction and hence a constant retarding force would be secured. But the coefficient of friction does change. It has already been pointed out that it decreases as the speed increases. Consequently, the minimum retarding force is obtained at the higher speeds. The stops from the higher speeds, therefore, tend to lengthen unduly.

The action needed to improve the stop distance is clear; that is, increase the brake-shoe pressure, and therefore the retarding force, at the higher speeds. But if this increased pressure is held undiminished throughout the stop, the retarding force will increase as the speed reduces and wheel sliding will be encountered at the lower speeds. The most modern brake equipments for high-speed service, therefore, are arranged to provide a variable cylinder pressure, so controlled that the desired retarding force is obtained at the higher speeds and yet wheel sliding is prevented at the lower speeds. Here again it will be noted that the air-brake equipment had to be changed, not because of any limitations within itself, but because of the demand for an improved overall braking performance.

From what has previously been said, it will be apparent that the brake-shoe pressures, or braking ratios, for these new high speed trains become quite high. Since

the coefficient of friction is low at high speeds, it is necessary to increase the shoe pressure to obtain the desired retarding force. But this increase in shoe pressure itself lowers the coefficient of friction. Consequently, a further increase in pressure is called for. This higher pressure means larger brake pins, and space limitations necessitate shortening the various members of the brake rigging, both of which tend to reduce the rigging efficiency. On this account, the cylinder force or the leverage ratio must be increased. The net result of this chain of influences is that very high braking ratios are employed in the most modern practice. As illustration, a few high-speed trains have arrangements for the use of 300 per cent braking ratio.

In conclusion, the foregoing presentation has discussed some of the fundamentals involved in braking but it should be understood that in actual practice, many other factors must be considered which are not here touched upon. The problem, as a prominent railway executive has put it, is an engineering one of the first magnitude. When attention is given to the fact that the modern brake may be called upon to dissipate, as an instantaneous maximum, well on to 2,000 hp. per axle, it is evident that the engineering problems encountered are many and difficult. These problems are constantly under scientific investigation and, with cooperation among the railroads and the manufacturers, there is every reason to believe that results can be produced which will be satisfactory.



Santa Fe passenger locomotives with 84-in. drivers, 23½-in. by 29½ cylinders and 300 lb. boiler pressure, develop 49,300 lb. tractive force.

Santa Fe High-Speed

Passenger Locomotives

Baldwin delivers six high-capacity 4-6-4 type locomotives with 84-in. driving wheels, one of which is streamline — For use on eastern lines

Six high-speed passenger locomotives of the 4-6-4 type have recently been delivered to the Atchison, Topeka & Sante Fe by the Baldwin Locomotive Works. One of these locomotives is streamlined. All are equipped for oil burning and are for service on the 992 miles of main line from La Junta, Colo., east to Chicago. The weight on drivers is 213,440 lb. and the total engine weight 412,380 lb. The driving wheels are 84 in. in diameter and the locomotives develop a tractive force of 49,300 lb., with a boiler pressure of 300 lb. per sq. in. The combined heating surface is 6,850 sq. ft. and the grate area (area inside the mud ring) 98.5 sq. ft.

The outstanding features of these locomotives are the use of special materials and structural features in the boiler to adapt them to the high steam pressure; the large diameter of the driving wheels, the bed casting, the unique engine-truck design and the fuel-oil tank, which is built into the water tank in such a way as to permit conversion to coal-burning with a minimum of structural change.

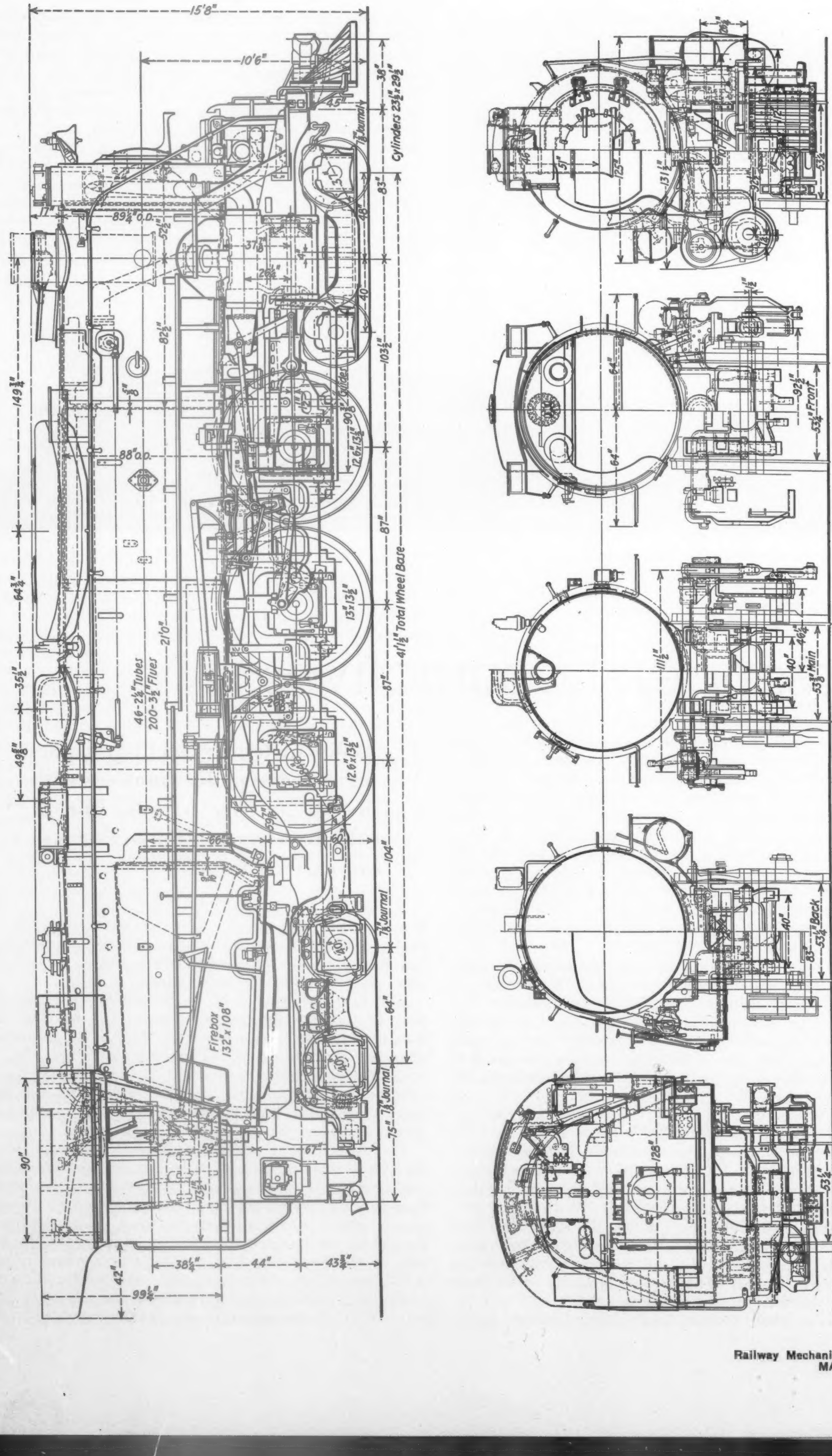
The Boiler

In point of boiler proportions these locomotives exceed any of the 4-6-4 type which have yet been built. They are first in total evaporative heating surface, superheating surface and grate area. With the exception of the Lord Baltimore of the Baltimore & Ohio, they also carry the highest boiler pressure of any existing locomotive of this type and their working pressure has not been exceeded by any locomotive boiler built with the staybolt type of firebox.

The boiler shell courses and outside firebox sheets are of nickel steel on all of the locomotives and in the case of the streamline locomotive a nickel firebox steel has been used for the inside firebox sheets. The boiler seam rivets are also of nickel steel.

The first shell ring is 88 in. in outside diameter. The plate in this and the second ring is 27/37 in. thick and that in the third ring, which is 91-7/16 in. in outside diameter, is 7/8 in. thick. The roof sheets are 13/16 in. thick, the back head 1/2 in., and the side sheets 7/16 in. thick. The inside crown and side sheet and the door sheet are 13/32 in., the back tube sheet 9/16 in. and the front tube sheet 5/8 in.

The firebox is of unusual width. It is 108 in. inside the side sheets and 132 in. in length, and the crown and side sheets are in one piece. There is no combustion chamber. Although not horizontal, the rear of the mud ring is only 7 in. higher than the front. The side water legs of the firebox are vertical for 18 in. above the bottom of the mud ring and the back door sheet is perpendicular 12 in. from the mud ring to facilitate the application of firebrick lining above the cast-steel draft pan. With the exception of the four rows on each side



Cross-section and elevation of the Santa Fe 4-6-4 passenger locomotives

at the break of the crown sheet and at the syphon flanges, which have solid heads, F. B. C. adjustable crown stays are installed. F. B. C. flexible bolts are also installed in the breaking zone and are hollow drilled for electric testing.

All longitudinal shell seams are seal welded for distances varying from 9 to 14 in. at the ends. The mud ring seams for the flue sheet, door sheet, back head, and throat sheet are seal welded for their entire length, and the calking edges between the door and side sheets are welded for a distance of 36 in. up from the bottom. The door flanges in the back head and door sheet are joined by a butt weld. The waist-sheet angles are not riveted to the boiler pads.

Principal Dimensions, Weights and Proportions of the Sante Fe 4-6-4 Type Locomotives

Railroad	A. T. & S. F.
Road Class	3460
Road numbers	3460-3465 (1 streamline)
Date built	1937
Service	Passenger
Dimensions:	
Height to top of stack, ft. and in.	15-8
Height to center of boiler, ft. and in.	10-6
Width overall, in.	131½
Cylinder centers, in.	92½
Weights in working order, lb.:	
On drivers	213,440
On front truck	83,950
On trailing truck	114,990
Total engine	412,380
Tender	396,340
Wheel bases, ft. and in.:	
Driving	14-6
Rigid	14-6
Engine, total	41-1½
Engine and tender, total	88-8
Wheels, diameter outside tires, in.:	
Driving	84
Front truck	37
Trailing truck	40
Engine:	
Cylinders, number, diam. and stroke, in.:	2-23½x29½
Valve gear, type	Walschaert
Valves, piston type, size in.	13
Maximum travel, in.	7
Steam lap, in.	1⅛
Exhaust clearance, in.	⅛
Lead, in.	5/16
Cut-off in full gear, per cent	86½
Boiler:	
Type	Straight Top
Steam pressure, lb. per sq. in.	300
Diameter, first ring, inside, in.	86 5/16
Diameter, largest, outside, in.	91 7/16
Firebox, length, in.	132
Firebox, width, in.	108
Height mud ring to crown sheet, back, in.	72
Height mud ring to crown sheet, front, in.	83 11/32
Thermic syphons, number	2
Tubes, number and diameter, in.	46-2¼
Flues, number and diameter, in.	200-3½
Length over tube sheets, ft. and in.	21-0
Net gas area through tubes and flues, sq. ft.	9.71
Fuel	Oil
Grate area, sq. ft.	98.5
Heating surfaces, sq. ft.:	
Firebox	280
Thermic syphons	95
Firebox, total	375
Tubes and flues	4,395
Evaporative, total	4,770
Superheating	2,080
Combined evap. and superheat.	6,850
Feedwater heater, type	Worthington
Tender:	
Style or type	Water bottom
Water capacity, gal.	20,000
Fuel capacity, gal.	7,000
Trucks	6-wheel
Rated tractive force, engine, lb.	49,300
Weight proportions:	
Weight on drivers ÷ weight, engine, per cent	51.75
Weight on drivers ÷ tractive force	4,33
Weight of engine ÷ comb. heat. surface	60.2
Boiler proportions:	
Firebox heat. surface, per cent comb. heat. surface	5.47
Tube-flue heat. surface, per cent comb. heat. surface	64.16
Superheat. surface, per cent comb. heat. surface	30.37
Firebox heat. surface ÷ grate area	3.81
Tube-flue heat. surface ÷ grate area	44.63
Superheat. surface ÷ grate area	21.18
Comb. heat. surface ÷ grate area	69.62
Gas area, tubes-flues ÷ grate area	.099
Tractive force ÷ grate area	500.50
Tractive force ÷ comb. heat. surface	7.20
Tractive force x dia. drivers ÷ comb. heat. surface	604.50

The boiler has a main and an auxiliary dome. The main dome is of cast steel and is solid, without cover. The opening in the auxiliary dome is large enough to permit a man to enter the boiler and on this dome cover are mounted the safety valves.

The boiler is laid out for an Elesco Type E superheater with 101 units, and the American multiple throttle is built into the header. The feedwater heater is the Worthington Type 6Sa. The heater unit is mounted in the top of the smokebox in front of the stack, the hot-water pump on the engine bed under the smokebox and the cold-water pump on the left side of the locomotive near the tender. Other equipment on the boilers includes the Signal Foam-Meter and Electromatic blow-off cock arrangement. The draft pan is fitted with a 3½-in. Booth burner.

The locomotives are fitted with box type spark arresters which are completely closed at the top, sides and bottom. The bottom rests directly on the exhaust pipe and the stack extension extends down through the top. The sides are curved parallel to the smokebox shell. The front of the arrester is open. A portion of the rear is completely closed with a large rectangular panel of double louvers, those at the rear running diagonally and those within the spark-arrester shell running vertically. The stack has a hinged extension top operated by a pneumatically actuated rack and pinion. The smokebox door ring is fitted with Okadee hinges.

The Engine Bed and Running Gear

The foundation of the locomotive is a bed casting with which the cylinders and back cylinder heads are integral. The casting also includes brackets or pads from which are supported the air pumps, hot-water pump, cold-water pump, the waist sheets, guides, valve gear and brake cylinders. Provision has also been included for the support of the stoker conveyor and grate shaker cylinders should occasion arise to convert the locomotives to coal-burning in the future. The front furnace bearer supports are also cast integral with the bed, as is also the attachment for the expansion-plate support at the rear end of the firebox. The main reservoirs are not included in the bed and the front bumper is a separate casting.

The driving wheels are Baldwin disc type cast-steel centers with the main wheels cross-counterbalanced. The journals are fitted with SKF roller-bearing boxes with 13-in. by 13½-in. journals on the main axle and 12.6-in. by 13½-in. journals on the front and rear axles. All driving boxes have ⅛-in. lateral play in the pedestals. The driving axles, as well as those on the engine-truck, trailer truck and tender trucks are carbon steel. The driving axles are hollow bored.

The front trucks on these locomotives have inside journal bearings and are of the Batz four-wheel design. This is an equalized type of unusual construction. The equalizer on each side of the truck is of the double type, both sides of which are cast integral with a spring pocket long enough to take eight single coil springs. Above the springs is a long cast-steel cap of inverted channel section which is located directly under the side member of the truck frame. The frame is carried directly by the spring cap on a rocker pin located on the transverse center line of the truck. Each equalizer terminates in a circular pad at each end which bears on a rocking plate in the top of the journal box. The clearance between the top of the spring cap and the underside of the truck side frame provides a limited freedom of movement of the equalizer.

The bolster is carried on constant lateral resistance rockers which are supported directly from the transoms of the truck frame. The truck has an initial lateral re-

sistance of 40 per cent and a constant resistance of $33\frac{1}{2}$ per cent. The center plate in the top of the bolster is lined and bushed with phosphor bronze and is lubricated. The engine and truck center plates are locked together by a 4-in. split-type center pin.

The journals are 7-⅞ in. in diameter and are fitted with SKF pedestal type roller-bearing boxes. The boxes have $\frac{1}{16}$ in. lateral play in the pedestals. The wheels are 37-in. in diameter.

The trailer truck is a four-wheel Delta type, all wheels being 40 in. in diameter. The outside journals are fitted with SKF roller-bearing boxes of the same journal diameter as those of the front truck. On the front axle the boxes have ⅛ in. and on the rear axle, $\frac{5}{16}$ in. lateral in the pedestals.

Partial List of Materials and Equipment on the A. T. & S. F. 4-6-4 Type Locomotives

Paint	(s) E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Bed casting	General Steel Castings Corp., Eddystone, Pa.
Boiler and firebox steel	Lukens Steel Co., Coatesville, Pa.
Staybolt iron	Ewald Iron Co., Louisville, Ky.
Flexible and radial staybolts	Flannery Bolt Co., Bridgeville, Pa.
Boiler braces	Ewald Iron Co., Louisville, Ky.
Rivets:	
Firebox	Burden Iron Co., Troy, N. Y.
Mud ring, back head and boiler seam	The Champion Rivet Co., Cleveland, Ohio
Smokebox door ring hinges	The Okadee Company, Chicago
Draft pan	General Steel Castings Corp., Eddystone, Pa.
Boiler lagging	(s) Johns-Manville Sales Corp., New York (3) United States Gypsum Co., Chicago (2) Standard Asbestos Mfg. & Insulating Co., Kansas City, Mo.
Steam-pipe covering	Union Asbestos & Rubber Co., Chicago
Nicholson Thermic syphon	Locomotive Fire Box Co., Chicago
Feedwater heater	Worthington Pump and Machinery Corp., Harrison, N. J.
Elesco Type E superheater	The Superheater Company, New York
Multiple throttle	American Throttle Co., New York
Steam and air gages	Ashton Valve Co., Boston, Mass.
Blow-off cocks	Crane Co., Chicago
Washout plugs	Huron Mfg. Co., Detroit, Mich.
Cab seats	Gustin-Bacon Mfg. Co., Kansas City, Mo.
Steam heat equipment; flexible metallic conduit at rear of tender	Vapor Car Heating Co., Inc., Chicago
Radial buffer and Unit Safety drawbar	Franklin Railway Supply Co., Inc., New York
Injectors	(s) Locomotive Equipment Division of Manning, Maxwell & Moore, Inc., Bridgeport, Conn. (5) Ohio Injector Co., Wadsworth, Ohio
Safety valves	Coale Muffler & Safety Valve Co., Baltimore, Md.
Signal Foam-Meter and Electromatic blow-off cock	Dearborn Chemical Company, Chicago
Sanders	(s) Viloco Railway Equipment Co., Chicago (5) Graham-White Sander Corp., Roanoke, Va.
Speed recorder	Weston Electrical Instrument Corp., Newark, N. J.
Bell ringer	Viloco Railway Equipment Co., Chicago
Headlights	The Pyle-National Co., Chicago
Turbo generator, Type SD-B	(s) Sunbeam Electric Mfg. Co., Evansville, Ind.
Main and side-rod forgings	A. Finkl & Sons Co., Chicago
Piston rods	Standard Steel Works Co., Burnham, Pa.
Piston heads and piston-head packing rings and universal sectional type bull rings	Locomotive Finished Material Co., Atchison, Kan.
Piston-rod and valve-stem packing, Diamond type	T-Z Railway Equipment Co., Chicago
Cylinder cocks	The Okadee Company, Chicago
Reverse gear, Type C	The Baldwin Locomotive Works, Philadelphia, Pa.
Engine truck (Batz) castings	General Steel Castings Corp., Eddystone, Pa.
Trailer truck, four-wheel Delta type	General Steel Castings Corp., Eddystone, Pa.
Driving wheels, disc type	The Baldwin Locomotive Works, Philadelphia, Pa.
Driving tires	Standard Steel Works Co., Burnham, Pa.
Driving boxes, roller bearing	SKF Industries, Philadelphia, Pa.
Trailer wheels	Standard Steel Works Co., Burnham, Pa.
Roller bearings, trailer truck	SKF Industries, Philadelphia, Pa.
Springs	American Steel Foundries, Chicago
Front bumper beam	General Steel Castings Corp., Eddystone, Pa.
Rod bushing and other bearing metals	Magnus Metal Div. National Lead Co., New York
Unit cylinder clasp brakes	American Steel Foundries, Chicago
Air brakes, No. 8ET	Westinghouse Air Brake Co., Wilmerding, Pa.
Train control	Union Switch & Signal Co., Swissvale, Pa.
Lubricators	Nathan Manufacturing Co., New York Ohio Injector Co., Wadsworth, Ohio
Rod-cup fittings, eccentric-rod and crank fittings, cross-head-pin fittings	Alemite Div. Stewart-Warner Corp., Chicago
Engine coupler	National Malleable and Steel Castings Co., Cleveland, Ohio
Flexible joints on steam-heat line (between engine and tender)	Barco Manufacturing Co., Chicago
Tenders:	
One-piece water-bottom casting	General Steel Castings Corp., Eddystone, Pa.
Tank steel	Lukens Steel Co., Coatesville, Pa.
Trucks, Pullman six-wheel type	General Steel Castings Corp., Eddystone, Pa.
Wheels and axles	Standard Steel Works Co., Burnham, Pa.
Springs	American Steel Foundries, Chicago
Roller bearings	SKF Industries, Philadelphia, Pa.
Coupler, Type E, and draft gear	National Malleable and Steel Castings Co., Cleveland, Ohio

Note: (s) Streamline locomotive.

The main driving springs have reverse camber. The front hanger is solidly connected to the bed casting, while the hanger at the rear of the trailer truck is connected through a double-coil snubber spring.

The main and side rods are of chrome-nickel-molybdenum steel with floating bushings at the back end of the main rod and both ends of the main connection side rod. Pressed bushings are used in the front side rods. The front end of the front side rod is set with $\frac{1}{16}$ in. lateral on the crank pin. The main crank pin is of nickel-chrome steel hollow bored to $3\frac{1}{2}$ in. diameter, the cavity being used as a grease cup. The front and rear pins are of carbon steel.

The piston heads are of special heat-treated alloy cast steel, with the Locomotive Finished Material combined Universal sectional type bull rings and packing rings of bronze and are carried on $4\frac{1}{2}$-in. quenched and tempered carbon-steel piston rods. The cross-heads and guides are of the Laird type, the latter fitted with the Slid-Guide attachment. T-Z packing is applied on the piston rods and valve stems.

The reciprocating parts on each side of this locomotive weigh 1,805 lb., of which 38.8 per cent is balanced. At 84 m.p.h. (diametral speed) the theoretical dynamic augment is 9,457 lb. per wheel in the front and rear pairs and 14,186 lb. per wheel in the main pair of drivers.

The valve motion is of the Walschaert type which drives 13-in. valves with a maximum travel of 7 in. The valves have one-piece bronze bull rings and packing rings. The link blocks are faced with phosphor-bronze bearing metal, deposited by electric welding. The reverse gear is the Baldwin type C.

Lubrication

Each locomotive is equipped with three force-feed lubricators. A Nathan type DV-7 36-pint lubricator with eight feeds and eight four-way distributors supplies oil to the pedestal faces of the engine truck, driving wheels and trailer truck. One distributor provides two feeds for each main guide. With the exception of the streamline locomotive, two Chicago 40-pint lubricators, one on each side, feed oil to the cylinders and valves. An extra feed on the left side lubricates the hot-water feed pump. The cylinder and valve lubrication on the streamline locomotive is provided by two Nathan DV-7 lubricators.

Alemite fittings are provided on all rod cups on the crosshead pins and on the eccentric crank pin. The flange oilers are the Swanson type.

These locomotives have No. 8ET Westinghouse air brakes with brake shoes on the drivers, trailing truck and tender. The braking ratios are 75 per cent on the drivers and 47 per cent on the trailer. The single 8½-in. cross-compound air compressor is mounted above the front deck of the bed casting at one side. The train-control equipment is the Union Switch & Signal Company's three-speed continuous type. Except for the streamline locomotives these engines are equipped with Pyle-National 1,000-watt, 32-volt turbo generators with dynamotors on the train-control equipment boxes. The streamline locomotive is fitted with a Sunbeam turbo generator with a dual-voltage generator.

The turret is mounted under a housing in front of the cab. Saturated steam is supplied through two 3½-in. extra-heavy pipes extending back from the dome to the turret; one pipe on each side, outside the boiler shell. Weston speed recorders are applied on all of the locomotives. The Unit Safety drawbar and Franklin type E2 radial buffer are applied between engine and tender.

The Tenders

The tender underframe is the General Steel Castings water-bottom type. This is arranged for the application of a submerged stoker trough and stoker engine in the left water leg should the locomotives subsequently be converted to coal burning.

The oil tank is integral with the water-tank structure. Conversion for coal can be made by removing the top of the oil tank over the coal space and substituting coal gates for the front oil-tank closure. Shapes and plates in the water and oil tanks are copper-bearing steel.

The six-wheel tender trucks are of the Pullman type, the castings for which were furnished by the General Steel Castings Corporation. The elliptic bolster springs are of chrome-vanadium steel. The rolled-steel wheels are 37 in. in diameter and are mounted on SKF roller-bearing axles. The tender trucks are fitted with Simplex unit cylinder clasp brakes.

The Streamline Locomotive

The streamline locomotive is covered with a light steel shrouding which is designed to blend into the contour of the train. The boiler shroud ends in a bullet nose at the front and the skirting below the running board covers the cylinders but does not cover the driving wheels and running gear. The sides of the cabs are fitted with removable sections to provide access to staybolts and there are doors in the boiler shrouding where needed for access to the equipment mounted on the boiler.

The shrouding is painted in two shades of blue with the under portion of the locomotive and tender, including the running gear, in black. An 18-in. stainless-steel strip, on which the words "Santa Fe" and the number "3460" are sand etched and filled in with black, extends from the front end of the locomotive to the rear of the tender on each side at running-board level. Other striping is in silver lead and the faces of the driving-wheel tires and hubs are finished with aluminum paint, as are also the tires of the engine- and tender-truck wheels. The handrails are of stainless steel. The handrail columns, cab handles and other exposed fittings are chromium plates. Rods and motion work are highly polished. The principal dimensions, weights and proportions of these locomotives are shown in the table.

The Locomotive Front End

(*Continued from page 87*)

fore be assumed that $G = 104$ lb. Therefore, we have

$$M_o = \frac{(R_o\ G\ FK)\ 0.93}{3600 \times H_s} \quad \ldots\ldots (27)$$

$$= \frac{70 \times 104 \times 0.0569 \times 13500 \times 0.93}{3600 \times 1192} = 12.12 \text{ lb.}$$

$$A_2 = \frac{12.12 - 2.76}{27.69} = 0.338 \text{ sq. ft.}$$

$$W_f = \frac{24.1 \times \sqrt[3]{0.338 \times 3600}}{\sqrt[3]{0.321} \times 70 \times 104} = 12.12 \text{ lb.} \quad \ldots\ldots (28)$$

and, applying equation (25)

$$W_f = [18 - (0.014 \times 104)]\ [0.84 - (0.001047 \times 104)] = 12.10$$

Since the value of W_f as found by equations (25) and (28) is substantially the same, we must conclude that the maximum weight of fuel which can be fired per square foot of grate area per hour under the given conditions is 104 lb., and the steam available for the cylinders is 43,600 lb. per hr. This example illustrates the uses to which Figs. 22 and 24 may be applied.

* * *

Photo by South African Railways & Harbors

This Garratt articulated locomotive represents the heaviest type of motive power on the 3-ft. 6-in. gage South African Railways

EDITORIALS

Does the Small Shop Need Good Tools?

Two circumstances combine to make life difficult for the man who has to operate the small railroad repair shop—the fact that it is usually located on a road which has limited appropriations and the fact that, not having any large-quantity-production problems to solve, those who are responsible for expenditures seem to "let him get along with what he has." The result is, in all too many cases, that the small shop finds it more difficult to do the work that must be done at a cost within the ability of the management to pay. The principal reason is that the margin between the permissible expenditure for labor and the actual cost of doing the work is usually so narrow that a slight change in conditions may seriously affect the ultimate result.

An analysis of the machine-tool problem of the small shop provides some exceedingly interesting facts. Take for example, the case of a shop recently studied where the appropriation for classified repairs allowed an average expenditure of about $4,200 for labor for each of less than 20 locomotives that would pass through the shop for repairs. That portion of the appropriation for labor that could be allocated to the machine shop for the entire year would buy, at the old wage rate, 9,120 machine-operator hours. Under the new, increased, wage rates the number of machine-operator hours that the appropriation would pay for is reduced to 8,590—530 less hours in the machine shop in which to do the year's work. Assuming that there is just as much work to be done, how are the 530 hours to be made up?

To carry this hypothetical analysis a bit farther, let's take the job of repairing driving boxes. First, we find, upon studying the analysis of operations that in a well-equipped shop somewhat larger than the one in question, the machine-tool operations on driving boxes accounts for between seven and eight per cent of the machine-hours for the entire shop. In the small shop we are discussing the total machine time per average box handled is about 400 minutes and for the 150 boxes handled in an average year the total would be 60,000 minutes, or 1,000 hours—11.7 per cent of the 8,590 hours that the management appropriated the money to pay for. If the small shop were able to perform the driving-box operations as efficiently as the somewhat larger shop mentioned above, in which the box machining time was between seven and eight per cent, it could have saved $325 on labor on the box job alone. An actual comparison, operation for operation, shows that the small shop requires 400 minutes of machining time to do a job that the larger shop does in 175 minutes.

The machine-tool problem of the small shop is not one of determining how to obtain maximum production on a quantity of parts. Therefore advantage can not usually be taken of specialized machines and tooling equipment. The job in the small shop requires that the few machines the installation of which can be justified shall be of a type and capacity that will assure the most efficient production on the great variety of work which must, of necessity, be put on them.

In any shop, large or small, a thorough analysis of the work to be done is vitally important. In the small shop such an analysis may disclose the fact that the difference between operating within appropriations and not doing so may lie in the decision to scrap two or three obsolete machines and replace them with modern equipment. Where the margin is so narrow failure to make the right decision may cost money which the management hasn't got. The small shop needs good tools.

The Train Limit Bill

For many years it has been the policy of the train-service brotherhoods to advocate legislation the effect of which is to increase the number of train-service employees required for the movement of a given volume of traffic. While such legislation has been proposed and advocated on the grounds that it is necessary for the removal of hazards to life and limb from railway operation, the consistency with which an increase in employment has been the most immediate and important effect has created a strong presumption that such, in fact, has been their main purpose. This applies to the eight-hour legislation, the various full-crew laws which have been advocated and some of them passed by state legislation and the train-limit legislation which has likewise been proposed in various states and is now pending in Congress.

Senate Bill S. 69, which limits freight trains to a maximum of 70 cars, passed the upper house of Congress last July and is now pending before the House of Representatives. Its effect upon the railroads is estimated, on the basis of 1936 traffic, to increase the freight-train miles in the United States by sixty million and the railways estimate an addition to operating expenses in excess of one hundred million dollars per year.

Usually when make-work legislation has been under consideration in the past, the safety claims of the proponents have not been subjected to critical analysis with clear-cut factual results. In the case of the present proposed train-limit legislation, however, such is not the case. L. K. Sillcox, vice-president, New York Air Brake Company, has made an exhaustive analysis of the records of railway accidents during the year 1936. In a paper presented before the gradual School of Business Administration at Harvard University on February 16, he discloses some of the results of his research. He classifies accidents in four groups according to the nature of their causes. There are casual accidents which, like those in any industry, increase with the number of employees and which will, therefore, be increased by any condition causing more trains to be operated for the movement of a given volume of traffic. Such accidents occur in boarding and alighting from trains; slipping and falling on cars or on the ground; in the regular performance of duty, etc. Boiler explosions and accidents in connection with the servicing of locomotives at terminals likewise increase with the number of locomotives required in the performance of a specific service. The second classification includes those causes unaffected by the size of train or manner of its handling, such as the failure of a rail beneath a train, causing derailment, or falling in connection with setting out cars at industrial sidings. The third classification includes shock accidents due to slack action, the situation with respect to which Mr. Sillcox points out has been improved by the present standards for draft gears and draft-gear maintenance and are being improved by the gradual installation of the AB brake. A fourth classification covers accidents resulting from misinterpretation of visual signals between the head and rear end of the train. The latter two are those in which the length of the train may be a factor.

Taking these classifications in order, there were 2,107 deaths in casual accidents which may be expected to increase with the number of employees, of which 1,273 were trespassers, 696 non-trespassers (mostly occupants of automobiles or pedestrians killed at grade crossings) and 138 employees. Of the 704 in the second group—those unaffected by the size of the train —620 were trespassers, four were non-trespassers and 80 were employees. In the case of the accidents caused by internal train shock, 20 were trespassers, none were non-trespassers and 12 were employees. No deaths were reported as due to misinterpretation of visual signals.

This analysis clearly indicates that any increase in the number of trains resulting from enforced limitation in the size of trains will cause far more deaths than will be saved, assuming that all of the 20 trespassers and 12 employees who lost their lives in accidents caused by internal train shocks were engaged in handling trains longer, rather than shorter, than 70 cars. Mr. Sillcox points out, however, that, but six of the 32 deaths of persons involved in fatal shock accidents (two of whom were railway trainmen) were caused on trains of over 70 cars. Furthermore, grade-crossing accidents, with 50 killed or permanently injured and 112 less seriously injured, were caused by trains of 70 cars or less, and but 45 of such accidents, with 20 killed or permanently injured and 42 injured, but not permanently, were caused by trains of 71 cars or more.

In the face of these facts, which clearly indicate the preponderant effect of the number of trains in determining the total list of annual deaths from railway operation, how can safety longer be claimed any justification for train-limit legislation?

Machinery Obsolescence Exacts Its Toll

The lamentable thing about obsolete railway machine tools and shop equipment is that it exacts its full toll of reduced production, regardless of whether management cannot or will not scrap it in favor of more modern equipment. In other words, when replacement funds are not available, railroads almost invariably have to pay, through increased repair costs and loss of serviceability of rolling stock, more than the purchase price of necessary new machinery which is not theirs even after they have spent the money.

Shop machinery depreciation reserves, designed to take care of wear alone, are far from adequate, judging from figures just released by the I. C. C. Bureau of Statistics, which show that in 1936 Class I carriers, exclusive of switching and terminal companies, spent slightly over $15,000,000 for shop machinery repairs whereas only $463,000 was set aside for machinery depreciation. The total investment in railway machinery is not exactly known but the depreciation rate is in all probability not over three per cent which assumes a service life of 33 1/3 years. True, shop machinery can be kept operating, from a mechanical standpoint, for even longer than that, *providing the manufacturers have not gone out of business and repair parts of that vintage are still obtainable.* Generally speaking, however, the cost of maintaining these old machines is excessive and represents a definite drain on the railway treasury, a fact well substantiated by the shop machinery repair bill for 1936.

Entirely aside from wear depreciation, there is the important factor of obsolescence. Since railway shops and enginehouses are not operated on a commercial basis and compelled to "shut up shop" when they fail to meet competitors' quality standards and prices, the mechanical-department officers, including shop managements, all too often seem to overlook or disregard obsolescence and its insidious hidden costs. They certainly have not the instinct or vision of the late Andrew Carnegie, who, in the classic example so often quoted,

scrapped 1½ million dollars worth of equipment in a new rail-rolling mill before it was ever used, simply because of a revolutionary improvement which came along and rendered it obsolete.

Mr. Carnegie could not afford to keep out-moded equipment in service, even when in the best of physical condition—and neither can the railroads. It is an unfortunate fact that railroads have to pay for obsolescence in shop machinery and tools even when they don't buy new ones.

The Trend in Calculating Air-Resistance Forces

During the developmental stages of engineering projects, one usually has to contend with diverse opinions advanced by different investigators and supported by a wealth of complicated mathematics—this has been true of the investigations undertaken to determine the power savings effected by streamlining railroad motive power and rolling stock. However, in this instance, it is noteworthy that in 1934, the American Locomotive Company, the American Car and Foundry Company, and the J. G. Brill Company combined their resources and efforts in promoting wind-tunnel tests of models at New York University, under the direction of Professor A. Klemin. The results of these tests were used to develop formulas for calculating the air resistance of full-size equipment, but as is often the case the formulas were quite complicated and so formidable that, in most cases, only engineers directly involved in design of streamline equipment were interested. Therefore, the simplification of these formulas became desirable. This has been accomplished by A. I. Lipetz, consulting engineer in charge of research of the American Locomotive Company, and his simplified formulas, with proof of their validity, were published in the October, 1937, issue of the A. S. M. E. Transactions.

The simplifying of the formulas reduces the complicated forms to a more usable basis, and although the aerodynamic engineer may criticize the method of reduction, the fact remains that simplified forms serve very well for estimating air resistance. The formulas recommended by Mr. Lipetz for calculating the air resistance of streamline locomotives and trains hauled by streamline locomotives, as well as the air resistance of standard equipment, all appear in keeping with experimental data and should be extremely useful.

Some engineers do not look with favor on the streamlining of steam locomotives because the streamline shroud increases the initial cost of the locomotive, it is not effective at common operating speeds, and makes maintenance more difficult due to decreased accessibility of locomotive parts. They also advance the argument that if the added weight of the shrouds were expended in developing a more powerful locomotive, the locomotive would have increased availability. However, these criticisms are not usually made to the streamlining of equipment propelled by internal-combustion engines. Regardless of such criticism, when engineers are given the opportunity of studying power saving effected by streamlining, which is made easier by the formulas developed by Mr. Lipetz, the advantages of streamlining become more and more obvious, especially since the tendency is undoubtedly toward higher scheduled speeds with still higher sustained speeds where track conditions are suitable.

Obviously, the gains to be obtained in reducing air resistance by application of streamline shrouds depends on the streamline design. The streamlining of locomotives in this country has been criticised abroad because some of it has been done with little or no regard for gains to be effected by reducing air resistance, which criticism on the basis of streamlining effectiveness is justified. However, such criticism is invalidated when one considers that the term "streamlining" is often applied for the want of a better word, such as "stream-styling," which implies that appearance of the locomotive has been changed to conform to a vogue of modern fashion—a change which admittedly has caught the public's fancy.

"Stream-styling" is undoubtedly but one step toward streamlining. There is no reason to doubt that complete streamlining cannot be accomplished with style, as evidenced by some of the power built in this country and abroad in recent years. Therefore, the aerodynamic problems being solved today by eminent research engineers through formulas readily usable by all engineers, regardless of their training and experience, is a step forward toward making streamlining and "stream-styling" synonymous. It is in this regard that we should appreciate the streamline-model tests of the American Locomotive Company, American Car and Foundry Company and J. G. Brill Company, and the expanding of the results to full-size equipment by means of simplified and usable formulas, as accomplished by Mr. Lipetz.

New Books

MODERN LOCOMOTIVES OF THE L. M. S. *By D. S. Barrie. Published by The Locomotive Publishing Co., Ltd., 3 Amen Corner, London, E. C. 4. 34 pages, 8½ in. by 5½ in., illustrated. Paper bound. Price, 30 cents.*

"Modern Locomotives of the L. M. S." reviews the history of locomotives of the London Midland & Scottish Railway from just prior to the amalgamation of the 130 or more British railways into four large groups under the Railway Act of 1921. It describes the development of many types of locomotives and gives details concerning numerous types, including the latest 4-6-2 streamline Coronation engine.

Gleanings *from the* Editor's Mail

The mails bring many interesting and pertinent comments to the Editor's desk during the course of a month. Here are a few that have strayed in during recent weeks.

Labor's Attitude

I presume what is uppermost in many mechanical peoples' minds today is the attitude of labor towards the management; in other words, the effort for organized labor to dominate shop policies to such an extent as to increase costs and decrease efficiency.

Plain Common Sense

An after dinner speaker recently said that the social and economic status of a man could be gaged by the frequency with which he changed his shirts—varying, say, from one a week to several each day. Bruce Barton, a member of Congress from New York City, put it in a more homely way in his recent message to the New York Railroad Club on the occasion of its sixty-fifth anniversary dinner. "Certainly," said Mr. Barton, "when an industry, which provides the best rail freight service in the world at the lowest average rates in the world, finds nearly 100 of its constituent companies and 28.1 per cent of its total mileage in the hands of receivers or trustees, it is time to 'Stop, Look and Listen.' Sound governmental regulation of transportation must, of course, continue. I believe that government must remain on top of such situations. It must make the rules, but at least the players are entitled to their board and an occasional change of socks and underwear."

Broaden Your Knowledge of Railroading

You speak of properly educating the public, which is a most essential undertaking. Before that can be done, however, the railroad man himself must be educated. Far too many officials, as well as employees, are completely absorbed in the routine details of daily work in their own circumscribed field, and show little or no curiosity concerning the basic principles underlying the daily routine. Many a man looks on his own particular department as the bright center of the railroad universe, without ever bothering to acquire even a smattering of knowledge regarding other departments, which might enable him to carry on a fairly intelligent discussion of current problems. While I am fully aware that railroading is a complicated business of many aspects, so that no one person can possibly be a complete master of the art, I still believe that the average railroad man would be a better salesman for the industry he represents, if he had a considerably wider knowledge of that industry.

The Foreman and Safety

We all have workmen who are not safety-minded. They may be slow thinkers, or are careless with their tools and shiftless with their personal belongings. Every foot of floor space in his department should be thoroughly checked by the foreman; everything should be cleaned up, materials and tools put in their proper places, the floors swept and a generally neat appearance maintained. Let the men know that you will not tolerate slipshod methods and that cleanliness must exist throughout your department. Just because things are cleaned up and in order, don't imagine you can forget safety even for a moment. The alert foreman should make frequent routine inspections, so that he may be assured at all times that he has done everything possible to prevent hazards of any kind. You may be criticized and it may even be intimated that you care more for a polished floor than you do for output. You will find, however, that your output will increase, with a better standard of work, and that your department will be free from costly accidents. If a foreman lets down in his part of accident prevention, the men will follow suit.

Proper Training for Apprentices

One of the most important problems today in the mechanical department is the proper training for apprentices. I feel that it should be given a lot of consideration. It is my belief that the more training that can be given an apprentice, the more benefit will be derived from this class of employee. When a young man is taken into a shop to learn the trade, he should be taken on probation for a given period of time. If it is found that he does not apply himself, he should be dropped from the service, since it is not treating the young man or the corporation right to allow him to continue at something he is not trying to improve himself in. There are many shops where boys are taken in to learn a trade and they just drift along for four years, after which they are supposed to be skilled mechanics, but are not, because of not getting the proper instruction during their course of apprenticeship. It is money well spent by any company to pay someone to look after the apprentices and organize them in classes to see that they take the proper interest in their work and get instructions that will enable them to fit themselves to become skilled workmen. The companies that are having someone follow up these young men and see that they get the right sort of training are the ones that are getting the best results. By so training these young men you are fitting them to handle the work ably and they will become assets to the company rather than a liability.

Most Useful Tool in Boiler Shop

What is the most economical and useful tool in the boiler department today? Some twenty-five years ago the problem was to keep diamond points, chisels, sets and rippers in usable condition, whether they were being used in the field or at the shop. In the field the common practice was to carry a large supply of such tools with many hammer handles. In the shop the difficulty was broken tools, with the everlasting cry of low air pressure—not losing sight of the fact that many eyes were lost, because goggles were not worn or were worn on the forehead. Today this condition, whether it be in the field or at the shop, has changed with the use of the oxyacetylene cutting blow-pipe. The unit consists of a supply of gases and a blow-pipe; this replaces the former equipment which consisted of diamond points, chisels, sets and much hard work and grief, at the same time doing the work in some five per cent of the former time. These facts make the oxyacetylene equipment almost indispensable in the boiler department of today. Many of our shops have oxyacetylene piped through a dual pipe line system, with outlets located at the most advantageous points. When a cutting operation is required it is only necessary to connect the equipment to these outlets and proceed with the work. For these reasons the most economical and useful tool in the boiler department today is the oxyacetylene cutting blow-pipe.

IN THE BACK SHOP AND ENGINEHOUSE

Building Up of Driving-Box Hub Liners*

By Irving T. Bennett†

Locomotive driving-box hub liners in some instances have been a source of trouble and expense to many railroads. It is more or less standard practice to cast standard bearing bronzes on the hub face of the driving boxes, depending upon dovetails, insert pins and other mechanical means for the proper fastening of the liner. Such methods produce a mechanical joint of uncertain value, particularly due to the fact that the bronzes employed, for the most part, possessed high shrinkage values. Moreover, the particular alloys used, while possessing good antifrictional properties, lack malleability and have poor resistance to pounding or impact loads.

The combination of a poor mechanical fit, together with the inherent lack of ductility very often results in service failures. It is not uncommon to require liner replacement several times between classified repairs, because the liners work loose, crack and fall out. Replacements are expensive, not only in labor and material but, furthermore, cause a hidden expense of considerable magnitude, depending upon the time the locomotive is out of service due often to this condition.

A careful study of the problem indicated the need for the liner to be securely fastened to the face of the box and also pointed toward the necessity of employing a metal of high physical values more suited to resisting shock and wear. It was natural, therefore, to consider the use of welding to affix the liner permanently to the surface of the steel box.

Table I — Physical Properties of Herculoy and Other Bearing Metals

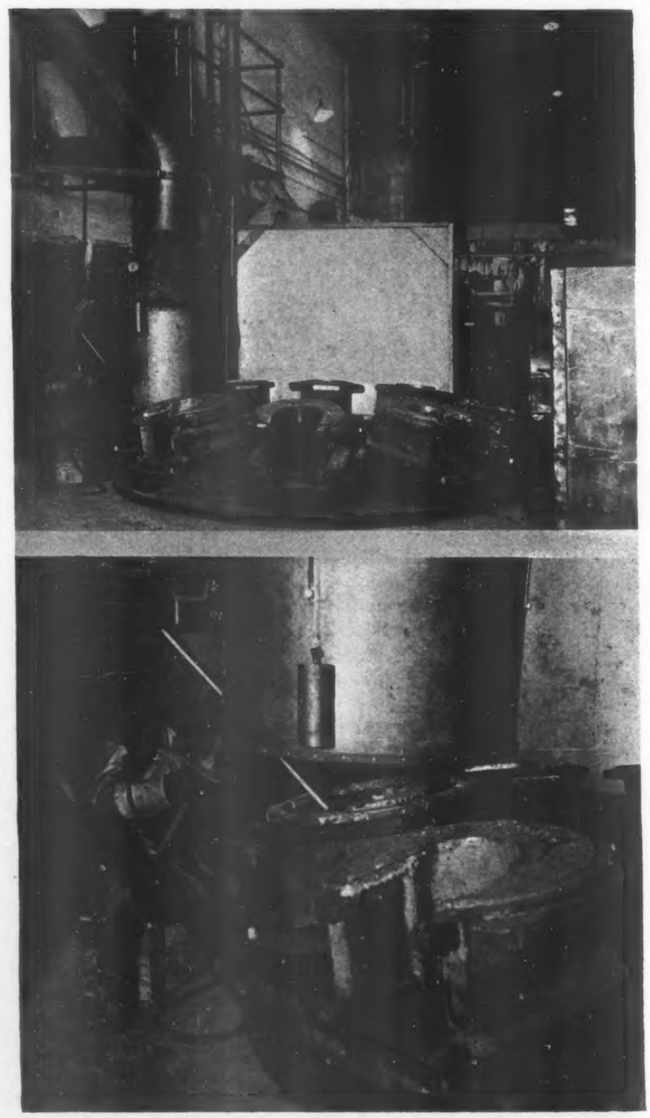
	Condition	Rockwell Hardness, C scale	Ult. tensile strength lb. per sq. in	Elongation, per cent in 2 in.	Impact Izod, ft.-lb.
Herculoy	Soft rod	91	63,000	72.0	...
	Drawn rod	105	72,000	50.0	...
	Cast	90	51,500	70.0	55.0
Leaded Herculoy	Cast	83	46,800	56.0	15.0
10-per-cent phosphor bronze	Cast	90	51,700	18.0	3.5
10-per-cent phosphor bronze leaded	Cast	85	45,900	16.0	3.5
Cu-Sn-Pb (80-10-10)	Cast	83	39,600	9.5	3.0
Cu-Sn-Zn (88-10-2)	Cast	90	44,300	10.0	7.5

Through the courtesy and assistance of the New York Central System, a test program was planned. One set of tests called for building up the entire face of the box by means of the electric arc, employing materials later described. A second test consisted of placing a plate of rolled metal on the face of the box and suitably welding it in place. A third series consisted of placing suitably designed segments of rolled material welded to the surface of the box on their edges and to each other. In undertaking this experimental program, several alloys were carefully investigated, the physical properties determined and a study made of the weldability of these alloys, coupled with an estimation of their wearing properties, particularly after deposition by the electric arc.

Table I shows the physical properties of the metals considered. The ease of weldability, high physical strength and high resistance to impact, led to the selection of Herculoy, an improved silicon-copper alloy of the following analysis: Copper, 96 per cent; silicon, 3.50 per cent; and tin, 0.50 per cent. Silicon is very efficacious in improving physical characteristics, its effect being several times that of tin. For purposes of comparison, test bars were made from cast material, as this was essentially in the cast condition. It will be noted that the Herculoy possessed the best combination of high physical properties and hardness with high impact values.

Test Results

It was expected that any of the methods employed would result in a liner which would remain permanently attached to the surface of the box, possess good wearing properties, extend service mileage and eliminate entirely the need of repair or replacement at the frequent inter-



Top: Set-up at the West Albany shops of the New York Central System for welding driving-box hub liners—Driving boxes are on turntable with a ventilating hood at the left—Bottom: Driving boxes in position for welding

* Abstract of a paper presented at the 18th annual meeting of the American Welding Society, Atlantic City, N. J., Oct. 18-22.

† Revere Copper & Brass, Incorporated.

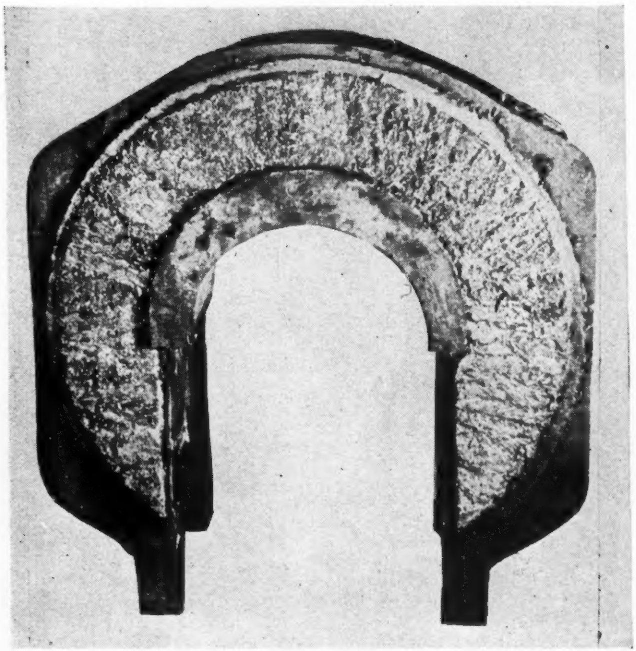
vals previously encountered when the old cast method was employed. The results of these tests were very positive in character and Table II indicates the wear found on the various boxes after 114,202 miles of service operation, which mileage on this particular railroad is that usually encountered between classified repairs.

It will be noted that the boxes built up entirely by means of the electric arc performed as well as the boxes on which the plates and segments were used. The use of the electric arc provided a very flexible and versatile method of accommodating all sizes and shapes of boxes with a minimum amount of inventory and, consequently, it was decided that this method was best adapted to the solution of the particular problem. Further tests pro-

Partially welded box viewed over the welder's shoulder—Backing ring, crown brass and asbestos dams in place

vided satisfactory checks and, as a consequence, the New York Central System adopted this practice as standard.

Further metallurgical developments were made whereby substantial amounts of lead were included in the deposited metal. Lead, present as such, materially improves the machinability of the deposits and, further, aids the antifrictional properties of the alloy. It was



Arc-deposited hub liner before finish machining

containing as high as 15 per cent or more of free lead, although in commercial application the lead content is less than this. The use of the electric arc, particularly the metallic arc, results in very uniform dispersion of the lead throughout the alloy; in fact, the uniformity is better than that commonly found in cast material.

Certain machining tests were conducted on driving boxes in which surface speed as high as 265 ft. per min. were used, which value is considerably in excess of normal machining requirements on a job of this character.

In an application of this kind, welding speed, coupled with well-bonded metal, was of paramount importance. One of the novelties of this work lies in the fact that metallic electrodes up to ⅝ in. diameter have been employed, although ½ in. diameter is most commonly used,

Table II — Performance of Herculoy for Hub Faces on Locomotive Driving Boxes

Three methods were decided upon:

1—Building up the face of the box by fusing Herculoy rod with the electric arc.
2—A solid liner plate of Herculoy welded to the box face.
3—A series of segments of Herculoy welded to the box face.

The above three methods were tried on the driving boxes of a J-1 type locomotive. Periodic check-ups were made during the regular quarterly inspection periods, and final inspection was made when this locomotive was unwheeled and made ready for shopping. The mileage was 114,202 miles. The following tabulation is self-explanatory:

Designation of Driving Box	Front R-1	Front L-1	Main R-2	Main L-2	Rear R-3	Rear L-3
Form	Rod-arc built all-way	Rod-arc built all way	Solid plate welded on	Solid plate welded on	Segments welded on	Segments welded on
Measurement from jaw face to box face, in.:						
Original	$2\frac{19}{32}$	$2\frac{19}{32}$	$2\frac{21}{32}$	$2\frac{21}{32}$	$2\frac{19}{32}$	$2\frac{19}{32}$
Final	$2\frac{19}{32}$	$2\frac{9}{16}$	(See Notes)	$2\frac{19}{32}$	$2\frac{9}{16}$	$2\frac{19}{32}$
Liner wear at point above jaws, in.	0	$\frac{1}{32}$	...	$\frac{1}{16}$	$\frac{1}{32}$	0
Approximate liner wear at top of hub face, in.	⅛	⅛	...	$\frac{7}{32}$	$\frac{1}{16}$	$\frac{5}{32}$
General appearance of liner face	Excellent	Excellent	...	Excellent	Excellent	2 Segments missing

Notes:

General appearance of wheel hubs:

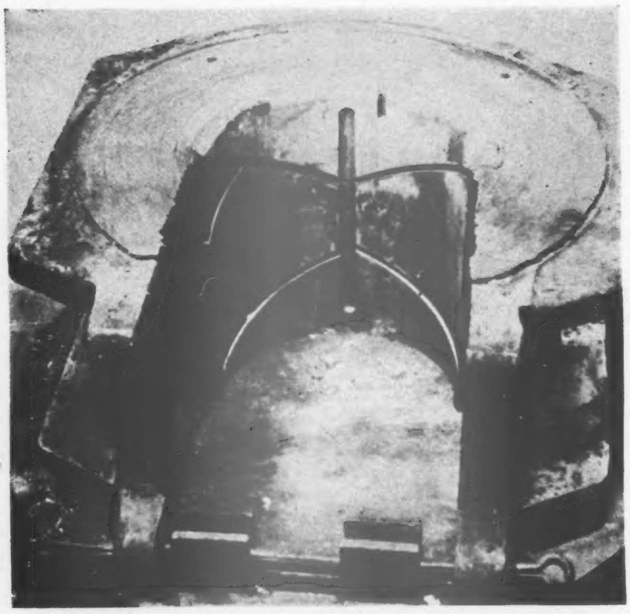
In every case, hubs were unmarked, bright and shiny; no evidence of cutting or galling.
The main box, right side, was taken out of service November 26, 1934, due to hot crown brass.
The rear box, left side, lost two segments. On this box segments were welded on edges only.

Conclusions:

1—From tests, observation and service, it is felt that Herculoy is ideally suited to application for locomotive hub liners.
2—It is possible to expect service from such liners from "shopping" to "shopping."
3—The rod method seems best adapted to this problem, although segments are satisfactory if welded on edges and middle.
4—Economies of considerable magnitude may be expected because of continued operation, also to the fact that but little work is necessary to resurface.

previously considered impractical to permit lead to be present in a welding rod, and in fact, all manufacturers' specifications very stringently covered this point by holding permissible lead in welding and brazing rods to only a trace. By the development of a proper welding technique, it was found possible to arc deposit alloys except on the Baltimore & Ohio, where ⅜-in. coiled rod is employed.

Experience has proved that the best procedure for applying Herculoy is with the metallic arc, using reverse polarity. Table III shows recommended practice. The metallic arc is more fool proof, in the hands of inex-



Typical welded hub liner after 115,000 miles of service returned for rewelding—Note the entire liner is present and wear is uniform

perienced operators, than the carbon arc. It is true that larger amounts of metal can be melted down with the carbon arc, but it requires proper technique and training to insure a proper bond of the metal so deposited. The bond with the metallic arc is inherent with the process. When using either process, suitable electrode

Table III — Recommended Practice for Welding with Herculoy

Rod size, in.	Metallic-arc current value, amp.		(Reverse polarity) closed circuit, volts
3/8	450		30-35
1/2	600		30-35
5/8	750		30-35
	Carbon arc		
	Carbon size, in.	Current, amp.	(Direct polarity) volts
3/8	5/8	450	40-45
1/2	3/4	600	40-45
5/8	1	750	40-45

holders must be employed and the operator protected with suitable clothing. Provision should also be made for the removal of welding fumes, since the large current values cause some volatilization of the metal.

Study was made covering the effect of varying rate of deposition on the character of the deposited metal, the efficiency of the deposition, spatter losses incurred and other pertinent factors. Tables IV and V show certain of the data developed. In conducting the deposition-rate studies shown, considerable difficulty was experienced in getting results that would be consistent as to the time and rate of deposition when using the carbon arc, whereas with the metallic arc, it was possible to duplicate the results very closely from test to test. The operation of the carbon arc depends greatly upon the operator's technique, and, if a firm bond is made to the underlying steel, the time required is about the same as when using the metallic arc. If it is just a question of seeing how much rod can be melted, the time is very much decreased by the use of the carbon arc, all of which is clearly shown on the tabulation.

Effect of Welding on the Driving Box

Some apprehension was felt by certain engineers regarding the structural changes taking place in the cast-steel surface of the box during a welding operation proceeding at high speed and with high current values. A box was prepared in the normal method and, after deposition, cut transversely into a number of sections which were carefully polished and checked for cracks and structural changes in the steel. Furthermore, analyses were made at various intervals to show the distribution of the silicon through the deposited metal, as well as to determine the extent to which iron migration occurred during the welding operation.

A detailed study of the steel surfaces disclosed no sign of cracks. There is a continuous gradation of temperature away from the bond, which produces a consequent gradation of grain sizes in the affected zone. Original structure is found about 3/16 in. from the bond. The photomicrographs show representative structures, but not the entire area of change.

Molten steel migrates into the deposit while it is molten and varies from near 10 per cent at the bond to 1 per cent 1 in. from the bond. The steel is fairly evenly distributed, as shown by micrographs and chemical analyses. The silicon content of the deposit is not effected to any great extent by the welding process.

The Baltimore & Ohio Methods

This article will give only a brief outline of the work actually done at certain railroad shops. The General Electric Company, in cooperation with the Baltimore & Ohio, developed an automatic arc welding head, using a 3/8-in. electrode in coil form. This automatic head is attached to a fixture similar to a small radial drill with a swing arm around the vertical column, which provides a horizontal adjustment and may be used by the operator to start his weld either from the inside or outside diameter of the box surface. The deposit may be as much or as little as desired, depending upon the regulation of the equipment. Under the swinging arm and adjacent to the column, the driving box is positioned upon a rotating table properly regulated to time itself with the feed of the electrode through the automatic head. In dealing with new boxes, the surface is suitably sand-blasted, following which the Herculoy is de-

Typical cast hub-liner failure—Note how the left portion of the liner has slipped around after cracking, and that the right-hand tip is missing

posited to any required dimension. It is reported that a new box can be built to full liner dimensions in approximately 1 hr. Boxes previously arc welded and requiring only one layer to compensate for lateral wear are welded in approximately 20 to 30 min. It is stated that mileage obtained before requiring lateral repairs

Table IV — Lead-Coated Herculoy Fusion Rods Time Studies

Diameter of rod, in.	Amp.	Volts	Electrodes used on 1-hr. operation, lb.	Comments
½	450	30	34.4	Good appearance
	550	35	45.0	Good appearance
	700	35	53.0	Good, but too hot
	800	40	62.0	Fair—too hot

Actual time to completely weld a J-1 driving box (dovetailed type):

Rod, in.	Amperes	Volts	Actual time	Amount of metal used, lb.
½	550	35	78 min.	46.5
½	700	35	55 min.	40.0
⅝	800	35	65 min.	51.0

On one of the complete boxes, a machine cut of ¼ in. was taken, and then it was resurfaced in one pass, using ½-in. by 24-in. rod at 600 amp., 35 volts. Actual time was 15 min., and weight of rod used was 9 lb.

ranges as high as 120,000 to 150,000 miles, a great deal, of course, depending on the class of service and the territory in which the locomotive is performing.

The New York Central Method

The New York Central apply material by means of the metallic arc manually operated. An interesting and effective method of handling boxes was developed by their engineers. Eight boxes are mounted on a revolving turntable, so the welding operation is practically continuous. While the welder is at work, his helper can unload previous boxes and mount the ones to be welded. Each box on the turntable can also be rotated and is

Table V — Deposition Rate Study of Lead-Coated Herculoy Rods

Process	Rod Diameter	Amp.	Volts	Lb. rod per hr. Used	Lb. rod per hr. Deposited	Per cent spatter loss	Lb. dep. per kw. hr.
Metallic arc..	⅜	380	30	28.49	27.79	2.43	2.44
		450	30	35.76	34.17	4.17	2.53
		500	30	38.72	36.72	5.16	2.45
Metallic arc..	½	500	30	43.10	41.30	4.17	2.75
		600	30	46.69	44.39	4.92	2.47
		700	33	54.99	50.57	8.04	2.19
Metallic arc..	⅝	700	33	62.46	57.78	7.50	2.50
		800	35	66.00	57.60	12.72	2.06
Carbon arc...	½	500*	42	47.96	47.96	0	2.28
		500†	42	97.68	97.46	0.20	4.64
		600*	42	65.25	65.25	0	2.59
		600†	42	128.13	127.84	0.20	5.08
		700*	45	139.04	138.72	0.20	4.40
Carbon arc...	⅝	700†	45	156.47	156.03	0.30	4.95

* Metal fused to base to insure good bond.
† Metal simply melted down in carbon flame and puddled.

mounted at an incline of 10 deg. with the horizontal. This permits "up-hill" welding, which is quite essential, due to the large current values employed, and permits the arc to work on new surfaces by preventing the mass of molten metal running ahead of the point of contact.

A counterbalance is provided for the rod holder and an exhaust applied over the box being welded.

A copper-faced steel ring is very successfully used to dam the edges of the box.

Rods are ½ in. diameter and are deposited using a current value of 650 amp. Old boxes with the dovetail naturally require more material than the new boxes. Speed of the operation is such that the old boxes are built to the proper dimension in approximately one hour's welding time. New boxes, requiring less metal, are built to proper liner thickness in approximately 40 min., whereas boxes coming in for resurfacing are usually welded in 20 to 30 min.

The original performance expectations on this railroad have been borne out, and it is practically unknown at this time to pull a locomotive out of service between classified repairs on account of undue lateral wear or hub-liner failure.

The welding supervisor of the West Albany shops of the New York Central System gave certain cost data before the New England Railway Club, which is repeated here:

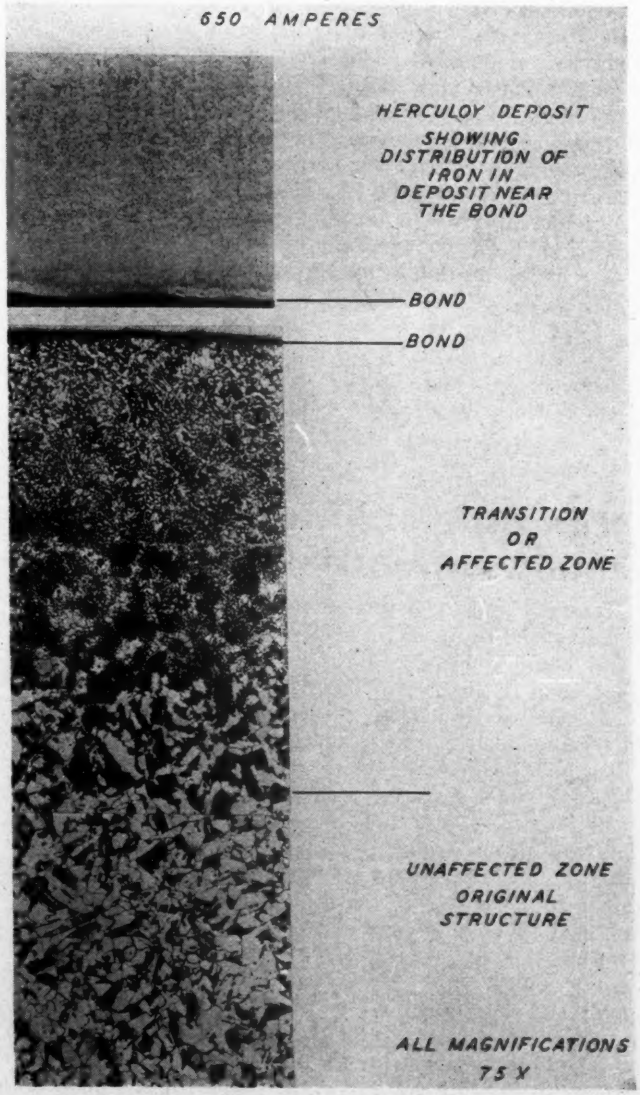
1. Original cost per liner on dovetailed box, material off and on, old style $9.00
2. Original cost per liner on dovetailed box, fusion welded 12.00
3. Original cost per liner on new boxes, fusion welded.. 6.00
4. Rebuilding cost per liner on fusion welded boxes 3.50

With the old method it was necessary to drop a pair of wheels on the average of 30,000 miles. At the present time, mileages as high as 120,000 miles, or from shopping to shopping, are obtained.

When the costs are calculated over two shopping periods and proper charges made, it is found there is a saving of $47.00 per locomotive in favor of the fusion welded job.

If new boxes are used, a far greater saving is found. The value in this case is estimated at $95.20 per locomotive in favor of the fusion-welded job.

A hidden saving of considerable magnitude is also found in the fact that the locomotive can be gainfully



Micro-section through a welded driving box

employed, rather than having the large capital investment laying idle, awaiting driving-box repairs.

Other Welding Applications

There are many other places in locomotive repair shops where welding rods and operations of the character described can be suitably employed. The combination of the electric arc and a suitable alloy produces minimum costs and maximum operating efficiency. Crosshead shoes, shoe and wedge faces and other places may be suitably built up and repaired using this method and this metal. Prolonged performance with minimum expense should result.

The inclusion of substantial quantities of lead in arc-deposited metals forces a complete revision of our thoughts on welding technique. Further developments, now under way, indicate that practically any of the recognized bearing alloys may be suitably deposited by means of the electric arc. Such depositions result in a bearing material which is in many cases markedly superior to the standard cast form. Due to the rapid chilling effects of the electric arc, the grain structure is very fine and the lead dispersion very thorough. The lead is present in small globules and more uniformly distributed throughout the mass of the deposited metal than in the case of castings, thus resulting in better physical properties and better bearing properties.

A research and test program indicates that arc-deposited bearing bronzes possess tensile strengths as great as 50 per cent higher than the same alloy cast or oxyacetylene deposited. The Izod impact values, a measure of toughness and shock resistance, are better than 50 per cent higher than cast bronze and over twice the values obtained from oxyacetylene deposits. The hardness values likewise are much higher for the arc-deposited metals and the loss of metallic constituents lower.

There appears to be much promise for arc-deposited bearing bronzes, and continued development and research will no doubt, extend our present knowledge and ability.

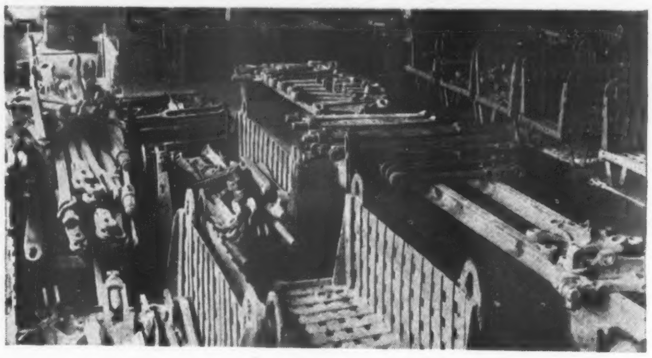
The author wishes to thank the New York Central, the Baltimore & Ohio, and the General Electric Company for permission to use certain data and information. Their cooperation is duly appreciated.

Handling of Material And Locomotive Parts

Materials and locomotive parts, at the Huntington locomotive shops of the Chesapeake & Ohio are delivered and handled by the supply department, which practice has been in successful operation for several years. All material used in repairing locomotives is taken and delivered as near as practicable to the point of use. Schedules have been worked out whereby delivery trains will leave various material sections at regular intervals and will set off loaded trailers or skids at designated points outside of the principal shop; these trailers or skids are then handled by trailers, lift trucks, or power trucks assigned to these shops. Material requisitions are telephoned to the delivery clerk's office, at which time the foreman states where the material is to be delivered, which point may be designated by engine number, pit number, shop machine number, or other special locations where space is available.

The supply department operates tractors or power trucks in each of the important shops for the purpose of distributing material, transporting material or parts from one location to another, and setting out loaded and empty trailers for the main-line tractor trains. The shop forces handle the movement of all material which can be moved economically with overhead cranes, wagons, and trucks.

The "spot" system is used in the Huntington shops on shop material transported from gangs to engines or other



Skids for handling brake rigging

points. Each foreman places material on the "spot" and a flat power truck picks it up on scheduled trips through the shop. When the material is too heavy to be handled by this power truck, a cross order is placed in the foreman's station box covering a request for handling the

List of Material-Handling Equipment at the Huntington Shops

No.	Type
TRUCKS AND TRAILERS:	
1	Gas-electric Hi-Lo
1	Gasoline truck
3	Electric tractors
1	Gasoline tractor
3	Power lift trucks with booms
3	Hand lift trucks
3	Crane trucks
3	Plain flat trucks
852	Trailer wagons, all kinds
SKIDS:	
30	Live skids with casters
357	Box type, factory made
2	Box type, shop made
10	Wood, box type, shop made, four-leg
10	Platform type, shop made, four-leg
24	Low box compartment, cab mountings
8	Oxyacetylene equipment
22	Driving springs
34	Air pumps
63	Brake rigging and spring rigging
4	For handling material when shipped by baggage
4	Feedwater Heaters
22	Engine jacket
1	Staybolts
1	Long, for rods
21	Engine diaphragm material
25	Tall, four-leg, for hot metal
MISCELLANEOUS TRUCKS AND WAGONS:	
8	Baskets for handling locomotive pipe at lye vat
25	Wagons for handling locomotive pipe from shop to storage. Pipe remains on wagons until returned to shop and applied to locomotive
4	Metal containers for handling journal bearings in locomotive tank shop
2	Wagons for handling storage batteries in the passenger-car shop
20	Wheel buggies for handling tender truck and car wheels
4	Wheel buggies for handling driving and trailer wheels
2	Lift trucks used in handling skids in blacksmith shop
1	Truck for handling rods and driving boxes
1	Truck for handling locomotive tires

load. A messenger boy, on an assigned route, picks up these cross orders and delivers them to the shop transportation foreman. These pickups from points outside the shops are telephoned to the transportation dispatcher's office.

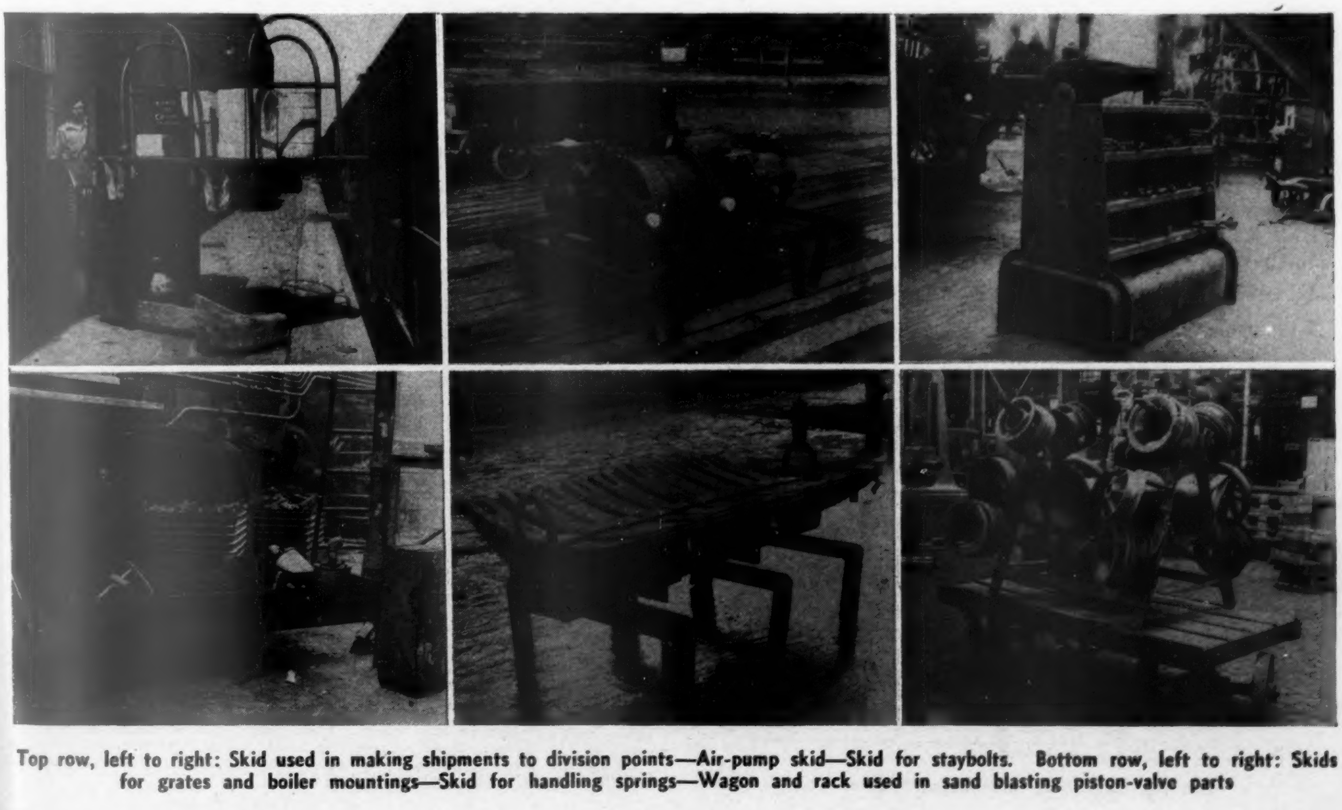
Central station from which all material is distributed

When empty trailers or skids are ordered to be placed for loading, the shop forces do the loading, and when loaded an order will be placed in the station box for movement. The supply department hauls the trailers or skids to their destination and where space is available, and when unnecessary handling can be eliminated, the trailer or skids will be left to be unloaded by the shop forces; otherwise, the trailers or skids will be unloaded by the supply department, except where shop cranes are available for this purpose. When the hauling is done on power flat trucks, the loading and unloading is done by the supply department, except where cranes are available.

A storage platform, located centrally at the south end of the blacksmith shop and east of the storeroom, is provided for empty trailers and skids; except those designed for a special purpose, which are stored near the respective shops. In order to relieve shop congestion and to provide sufficient equipment, all trailers and skids are promptly unloaded and returned to storage places, unless unnecessary handling of material is involved.

Cleaning Shops and Handling Scrap—The mechanical department provides sufficient force and supervision to do the general shop cleaning on the first shift. A sufficient number of trailers are placed in the shops to handle all scrap and debris, the loading of which is done by shop forces. The handling and unloading is done by the supply department forces on the first shift. The shops are operated on a five-day week at present. A necessary force is retained on Saturdays to clean the shop and handle material in the shop.

Equipment—Equipment for handling material in the shop, storing and shipping materials to outside points consists of a number of different designs of skids which are handled by power lift trucks. In some instances these skids are used to ship bulk manufactured materials, such as rivets, brake shoes, and journal bearings to the general store. A list and description of the equipment



Top row, left to right: Skid used in making shipments to division points—Air-pump skid—Skid for staybolts. Bottom row, left to right: Skids for grates and boiler mountings—Skid for handling springs—Wagon and rack used in sand blasting piston-valve parts

now being used in handling material, scrap, and debris, is given in the accompanying table.

Machines for Handling Material—Of the physical equipment furnished the stores department for storing and shipping materials, the lift and platform powered trucks are most useful. The skid boxes are used for storing material at the general storeroom, for shipping materials to outside points, and for shipping bulk materials such as rivets, brake shoes, and journal bearings from the point of manufacture to the general storerooms. With the use of platform and lift trucks the loaded skid boxes, containing from 3,000 to 6,000 lb. of material, can be moved in and out of cars and from storeroom to points of use with less human effort than was formerly required to handle a 200-lb. keg of rivets or bolts.

Dump wagons used in handling shop refuse, sand and gravel

Locomotive Boiler Questions and Answers

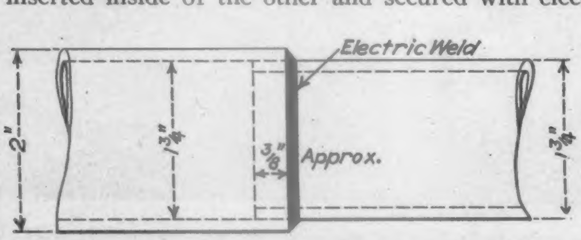
By George M. Davies

(This department is for the help of those who desire assistance on locomotive boiler problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless special permission is given to do so. Our readers in the boiler shop are invited to submit their problems for solution.)

Safe-Ending Flues of Different Diameters Not Recommended

Q.—The accompanying sketch shows a method of safe ending locomotive flues with a smaller diameter flue, the small end to go in the firebox tube sheet. This will eliminate swedging the tube and will also get more water to the firebox tube sheet. I would like to have your comments on this method.—M. McN.

A.—In this design, the chief difference from the conventional manner of safe ending flues, is that one tube is inserted inside of the other and secured with electric weld on the outside, while the conventional manner is to butt weld the safe end to the tube in an electric flue welder. Of the two methods I believe that butt welding the safe ends in an electric flue welding machine would be the most economical even when taking the swedging operation into account. In the proposed method, the variations in the diameters of the tubes would have to be taken into account if a snug fit is to be obtained. The chief objection would be that the safety of the structure is dependent upon the strength of the weld, and before making any application of safe ends in accordance with the method outlined, I would suggest the sketch be submitted to the inspector, under whose jurisdiction the flues come, for approval.



Can this method of safe ending flues be used?

Types and Efficiencies of Longitudinal Seams

Q.—What are the different types of longitudinal seams used in locomotive boiler construction?—V. J.

A.—Four different types of longitudinal seams are in use, viz., sextuple, octuple, decuple and diamond-shaped seams, the first three being the most common. In the order named, they have approximate efficiencies of 82 to 85 per cent, 87 per cent, 93 per cent and 98 per cent. The diamond seam, at almost 100 per cent efficiency would appear to be the most advantageous and does reduce the thickness of the shell, thereby reducing the weight and cost of the plates; however, the inner welt of this type of seam has to be quite extensive in size, and the weight saved in the shell itself is mostly replaced by the weight of the inner welt strip. The size of these welt strips is also a disadvantage in that it frequently causes the strip to interfere with some accessory or fitting requiring rivet or stud bolts in the shell. Furthermore, to place these holes through the seam in line with any of the seam rivets in the inner welt strip would reduce the efficiency of the seam.

Steam Evaporated by Different Boiler Sections

Q.—Have you any late data on the large up-to-date locomotive boiler pertaining to generation of steam? I would like you to give a comparison of steam evaporated by the different sections of the boiler.—J. C.

A.—The heating surfaces of firebox boilers of the locomotive type are classified according to direct and indirect heating surfaces. The crown, side, door and flue sheets and arch tubes are exposed directly to the fire; therefore, they are known as direct heating surfaces. The tubes and flues are exposed to the heat from the gases

Evaporation From Tubes and Flues of Various Diameters and Spacings

	Tube or Flue Diameters, in.								
	2			2¼			5⅜ and 5½		
	Spacing, in.			Spacing, in.			Spacing, in.		
	⅝	¾	1	⅝	¾	1	⅝	¾	1
Length, ft.	Evaporation, lb. per hr. per sq.ft. of outside surface								
15	9.44	9.97	10.80	10.02	10.51	11.29	11.55	11.65	11.90
15½	9.27	9.78	10.63	9.83	10.33	11.09	11.35	11.46	11.71
16	9.10	9.60	10.44	9.67	10.15	10.90	11.17	11.28	11.52
16½	8.94	9.42	10.25	9.50	9.97	10.71	10.99	11.11	11.34
17	8.78	9.27	10.07	9.34	9.80	10.55	10.82	10.94	11.16
17½	8.62	9.11	9.89	9.18	9.63	10.35	10.65	10.77	10.99
18	8.47	8.95	9.72	9.03	9.46	10.18	10.49	10.60	10.82
18½	8.32	8.79	9.55	8.88	9.29	10.01	10.33	10.44	10.66
19	8.18	8.63	9.38	8.73	9.12	9.84	10.17	10.29	10.51
19½	8.04	8.47	9.21	8.58	8.97	9.68	10.02	10.14	10.35
20	7.90	8.32	9.05	8.44	8.83	9.51	9.88	10.00	10.22
21	7.63	8.02	8.73	8.15	8.55	9.19	9.60	9.72	9.94
22	...	...	...	7.90	8.28	8.90	9.33	9.44	9.66
23	...	...	...	7.66	8.03	8.62	9.08	9.18	9.38
24	...	...	...	7.42	7.78	8.35	8.83	8.94	9.12
25	...	...	...	7.20	7.55	8.10	8.60	8.70	8.90

Note: By spacing is meant the distance between the tubes or flues after they are installed in the boiler. This should not be confused with the spacings in the tube sheet between the holes, which is known as the bridge; the spacing between the tubes is different from the bridge distance because of the swedged ends of the tubes.

which pass through them, but not directly to the fire; therefore, their surfaces are considered as indirect heating surfaces in calculating the entire heating effect.

Tests have shown that a heating surface in a horizontal position is more efficient than an equal area of vertical heating surface and that a heating surface in direct contact with the fire will evaporate water at a higher rate than an equal area subject to indirect heat. The heating surfaces of the firebox of locomotive-type boilers will evaporate about 55 lb. of water per sq. ft. of heating surface per hr. The evaporation by the tubes and flues is estimated roughly about 10 lb. per sq. ft. of outside surface per hr. The actual evaporation by tube and flue surface is variable, depending on their diameter, length and spacing. Some of the values of water evaporated per square foot of outside heating surface per hour for some tube sizes and spacing are given in the accompanying table. These data were compiled by the American Locomotive Company.

Flame Cutting of Rivets and Staybolts

Q.—What is the best procedure for cutting out rivets and staybolts with an oxyacetylene torch?—M. K.

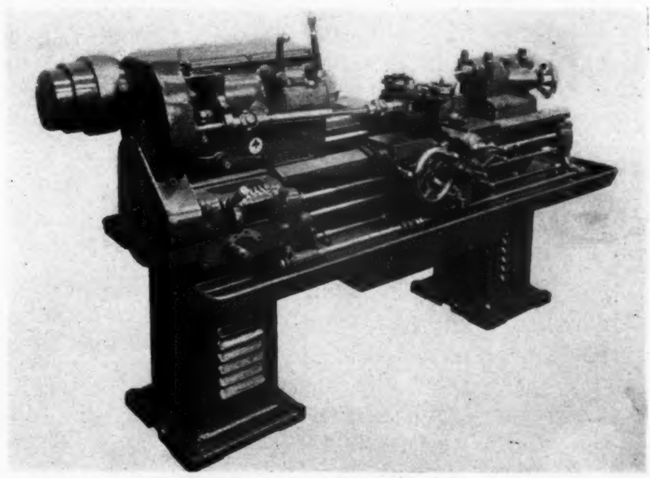
A.—In removing staybolts by the flame-cutting process, the tip is held in line with the bolt, so that the preheating flames contact and heat the edge of the telltale hole. When heated sufficiently the cutting oxygen is turned on gradually. The blow pipe is slowly rotated around the telltale hole until the center of the bolt is consumed for a depth of 3/8 in. The direction of the cut is changed 45 deg. and the bolt pierced through to the water space. By slowly rotating the torch or blow pipe at the same angle the bolt is cut without damage to the sheet of threads. The small burr remaining the sheet is then removed. There are several other fast economical methods of applying the flame-cutting process to this operation which can be and are used to meet special jobs or shop conditions.

In rivet cutting by surface oxidation of heads, the cutting tips used have large cutting oxygen orifices of the expanding low-pressure low-velocity type, together with high-intensity preheating flames. The tip is held in line with the rivet, close to the head, so that preheating flames impinge on its center. As soon as a spot is heated to a bright red, the cutting oxygen is turned on slowly. This quickly oxidizes a crater in the head and consumes it. The shank of the rivet is then knocked out of the hole. Preheating and oxidation of the rivet head require only a few seconds and unusual speed and economy are secured by this method, particularly where large quantities of closely spaced rivets are cut. The low velocity and pressure of the cutting oxygen are insufficient to cause the molten slag to fly back against the end of the tip and plug up the holes so that the torch need not be raised when turning on the cutting oxygen. Plates or sheets are not scored by this improved method.

Relieving Attachment For Tool-Room Lathes

The R. K. LeBlond Machine Tool Company, Cincinnati, Ohio, has developed a universal relieving attachment for tool-room lathes which increases the application of the lathes with the use of only two cams, makes it possible to obtain any relief from zero to 1/4 in., and provides means for accomplishing external, cylindrical, internal, end, side, angular and spiral relief. The majority of the work within the range of the attachment can be handled without angularity of the knuckle joints which, under the most extreme conditions, assume only a slight angle. No supporting blocks or additional knuckle joints are necessary to change from external to internal or end relief; for spiral relief it is only necessary to make a simple adjustment of the change-gear combinations. With the built-in coarse threading attachment, which is always furnished with the relieving attachments, most of the change-gear combinations can be made directly from the quick-change box.

The driving mechanism is attached to the headstock



The LeBlond tool-room lathe with relieving attachment

and in no way interferes with the operation of the lathe for ordinary work. The drive from the gears on the end of the lathe is through a telescopic shaft to the actuating mechanism on the tool slide. The tool slide replaces the regular compound rest and incorporates the same swivel feature, enabling the operator to swivel the slide to the proper angle for angular, side and end relief.

The actuating mechanism is driven by a pair of hard-miter gears, one of which is keyed to the cam shaft. The driving gear can be swiveled about the center of the driven gear since it is mounted in a swivel bracket with a positive means for clamping it in the desired position. With this construction, the driving shaft remains straight regardless of the angular setting of the tool slide.

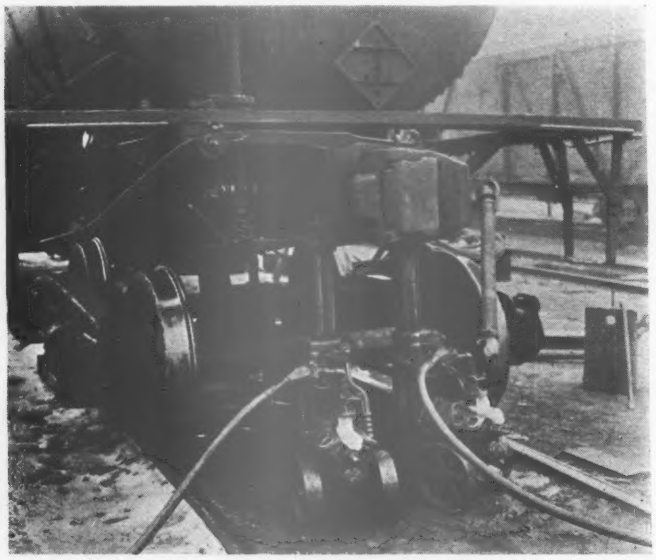
The driving cam, revolving constantly, imparts an oscillating motion to the follower cam that is mounted on the vertical eccentric shaft which may be adjusted in relation to the follower cam by the square milled on the upper extension of the shaft. This shaft, which is oscillated under the influence of the master cam and follower cam, imparts the reciprocating motion to the tool slide by means of the eccentric which is formed on it and a positive connecting rod to the tool slide. The motion imparted to the eccentric shaft being constant, the variation in the stroke of the tool is accomplished by adjusting the eccentricity of the vertical shaft in relation to the follower cam. As the line of eccentricity approaches parallelism with the ways of the tool slide, the stroke of the slide is decreased, and when adjusted to the maximum effective throw of the eccentric, the stroke of the slide is lengthened to provide the greatest amount of relief.

The driving gears are completely guarded. An extra compound rest and standard tool post are regularly supplied with each lathe equipped with the relieving attachment.

With the Car Foremen and Inspectors

Wheel Changes Expedited

In making wheel changes at the Chicago & North Western car-repair tracks, South Proviso, Ill., the first operation, namely, jacking the car, is greatly expedited by the use of power jacks, which are especially helpful in the case of cars with heavy loads. Two of these jacks, shown in one of the illustrations, are of the Joyce-Cridland 50-ton type, operated by directly-connected Ingersoll-Rand air motors. These motors operate simultaneously, being connected to the same air line through a single valve. Both sides of the car are accordingly raised at the same rate and a mechanical over-travel trip is provided to avoid any possibility of the car body being jacked above a safe height. When it is desired to lower the car body, each jack is set in reverse and continued operation of the air motors lowers the load. These jacks are provided with substantial bases so as to require a minimum of blocking. Safety is assured since the load is fully sustained, even in the event of loss of air pressure.



Power-operated jacks raising a loaded tank-car body preparatory to changing the wheels

It is difficult to estimate how much saving will be accomplished by modern power-operated jacks in car-repair yards. With the larger capacity jacks the rate of lifting the load is relatively slow and possibly not much faster than would be the case with hand-operated jacks. From the point of view of manual labor involved and safety, however, there is no question that the power-operated jacks are vastly superior.

While the principle of the truck assembling and dismantling device is by no means new, the particular design, illustrated in two views, is notable for its rigidity, relatively light weight and the fact that it can be readily separated into three pieces and, therefore, easily moved from one part of the repair track to another. The general dimensions of the device are fairly well standardized, it being 10½ ft. wide between side frames, 69 in. high under the lower horizontal cross pipe and 84 in. high overall. To assure maximum strength combined with light weight, welded tubular construction is used throughout.

Each A-type side frame is made of two pieces of 1¼-in. extra-heavy pipe, bent parallel at the top where they are welded together and reinforced with two 5-in. by 10-in. steel cover plates. The inner plate is machined or cut away so as to form a T-slot, 8 in. long, which accommodates a T-iron connection rigidly welded to the ends of the cross pipe assembly. The closeup view of the device shows a car man slipping one end of the cross pipes into the T-slot in the A-frame. The A-frames are braced with 1-in. horizontal pipe sections, located about 30 in. above the ground, and each pipe leg is covered at the bottom with a 2-in. circular steel plate, welded in place and providing adequate support for the device on reasonably firm ground.

The horizontal cross-pipe assembly consists of 2-in. extra heavy pipe, made in the form of an inverted truss and braced with three 1-in. pipe struts welded in place. As usual, a lifting device is provided at each of three points so that the truck bolster and two side frames may be lifted simultaneously, and the latter moved along the horizontal cross bar in dismantling and reassembling the truck. A ¾-in. turn buckle, with extension handle is suspended from a 5-in. shieve wheel at each end of the device, being, therefore, capable of easy movement horizontally within the necessary limits in moving the side frames. The connection of the center lifting device is of unusual interest owing to the fact that the Coffing chain hoist is suspended from a spring-supported steel yoke made of ⅝-in. stock, which completely surrounds the cross-pipe assembly and, therefore, serves as a safety loop in case the spring connection fails. This feature is best seen in the close-up view already referred to.

Method of applying the cross-pipe end in the A-frame T-slot

The advantages of this general type of truck assembling and dismantling device have been quite thoroughly demonstrated. Not only are wheel changes made quicker and all truck repairs expedited, but the greater ease of removing side frames enables this operation to be performed with less danger of damaging the journals or injuring fingers and hands. A substantial reduction in the cost of wheel changes and truck repairs is effected by the use of this truck assembling and dismantling device.

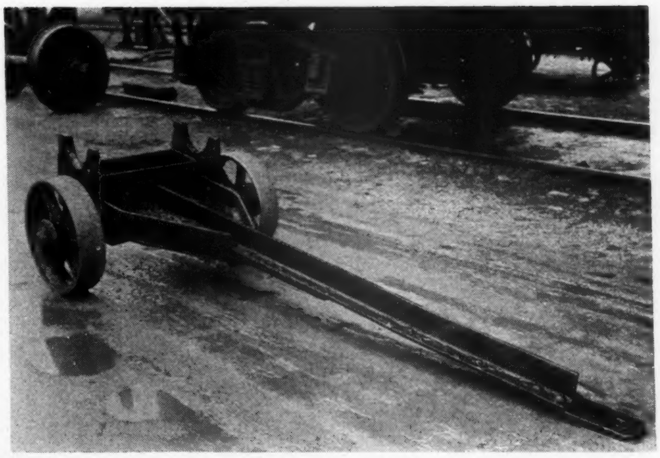
Wheel trailers of the type shown in the last two illustrations are used at the South Proviso car-repair yards to facilitate handling wheels to and from storage tracks. This two-wheel trailer is very substantially made of steel,

Truck assembling and dismantling device notable for light but strong construction

so proportioned and designed that it can be pushed under a pair of car wheels resting on the ground, at which time the tongue of the trailer extends upward at an angle of about 45 deg. Simply pulling down the tongue has the effect of raising the wheels clear of the ground, after which the tongue can be coupled to a tractor and the car wheels moved wherever desired about the repair tracks.

Referring to the view of the trailer unloaded and

Two-wheel trailer and tractor used in moving car wheels about the car-repair yard



The car-wheel trailer

uncoupled from the tractor, its general construction is apparent. The axle is 42 in. long, overall, and the roller bearing wheels are 18 in. in diameter with 4 in. threads. The tongue, a 4-in. T-iron, 7 ft. long, is riveted securely to the steel trailer body, made of a section of ⅝-in. steel plate reinforced with 4-in. bent angles, to which the 1-in. axle-supporting plates, spaced 24 in. apart are firmly riveted. Half-round recesses, 7 in. in diameter, are cut in the side plates so as to support the bottom of the car axle 18 in. above the ground. Between the side plates and under the axle there is just room for a small steel box which provides a convenient means for carrying car brasses, truck bolts, etc. The trailer is hauled by the usual power-operated tractor and its use assures the safe and satisfactory handling of car wheels about the repair tracks.

Car Service Rules And Per Diem Rates*

By J. L. Brown†

With every index pointing to higher costs for materials and supplies, higher labor costs and higher taxes, it is quite apparent that we must secure the maximum use for all classes of equipment.

The first car service rules became effective about 1893. They are fundamentally the same now as they were then, with improvements and additions as experience has indicated was necessary. These rules were adopted at a time when mileage payments were the basis of car rental. On July 1, 1902, the per diem plan became effective with rates varying from 20 cents per car per day with a penalty rate when cars were detained more than 30 days, rates being increased or decreased until March 1, 1920, when the rate was increased to 90 cents per car per day, subsequently increased on November 1, 1920, to the present rate of $1.00 per day, with the exception of May 1, 1935, to June 31, 1937, when the rate on plain and ventilated box cars was settled for on an arbitrary, based on monthly averages, because of the adoption of the average per diem plan on this class of equipment.

It is appropriate at this time to call attention to the fact that on May 1, 1917, all A. A. R. car service rules

* Abstract of a paper presented at the December, 1937, meeting of the Car Foremen's Association of Chicago.

† General superintendent transportation, Chicago, Milwaukee, St. Paul & Pacific, Chicago.

Car service rules and per diem rates have an important bearing on the service secured from freight cars

were suspended by general order CS-1. In June, 1919, the Committee on Car Service, Transportation Division, together with representatives from several regions, formulated a code of car service rules to govern the handling of freight cars upon the termination of federal control. These rules were based on the original principles of ownership.

They were adopted by the association March 1, 1920, on release from federal control and their application became a matter of signed agreement executed by the executive officer of each railroad, a copy being filed with the Interstate Commerce Commission. In this agreement there was added further flexibility under per diem Rule 19, with the appointment of the Car Service Division who were given authority to supervise and suspend the rules and to provide other regulations under which cars shall be handled. This action might become necessary under extraordinary conditions.

Because of experience under these rules, the Board of Directors of the A. R. A. on January 6, 1921, passed the following resolution:

"That the Transportation Division be requested to bring in as soon as possible a set of car service rules which will bring cars home under reasonable conditions and without unnecessary delay, or back haul or otherwise, and with adequate penalties for non-observance, the division to be requested to consider the question of equity as between loaded and empty car."

On July 1, 1921, the present car service rules with slight exceptions were adopted and with the $1.00 per diem rate effective November 1, 1920, provided an incentive to expedite the movement of equipment to owners' rails.

The car service rules at present total 17. The most important, in my opinion, resulting in proper car handling, are Rules 1, 2 and 3.

Rule 1.—Covers what is known as "home cars," for example, a Milwaukee car on Milwaukee rails. These cars should not be used for the movement of traffic beyond the limits of the home road when the use of other suitable cars is practicable. The last two words "is practicable" have their opponents as well as defenders. A sincere effort in the application of this rule will accomplish much. A mere review of car location statements does not indicate a compliance or non-compliance. Conditions on many lines vary and reasonable latitude as to the use of foreign and home cars, with due regard to size, condition and type of cars, peak and valley seasonal movements, loaded and empty car mileage, and all other factors adversely effected by an iron-clad rule must be considered.

Rule 2.—Covers foreign cars at home on a direct connection, for example, a B. & O., C. & N. W., or C. B. & Q., car located on Milwaukee rails, these being cars of direct connections. This rule provides some seven ways in which to dispose of such equipment either loaded or empty.

An important part of this rule provides: "If empty at junction with the home road and loading at that point is not available, such cars must be delivered to owner at that junction, unless an exception to the requirement be agreed to by roads involved."

An honest compliance with this provision will materially help the car supply of the owners; will be helpful in reducing car service rule violations, and in many cases be of assistance in reducing the ratio of empty to total car miles.

Rule 3.—Takes care of foreign cars on other than direct connections and provides for proper handling of such equipment. For example, cars owned by the New Haven, the Florida East Coast or the Texas & Pacific, located on Milwaukee rails, are cars of other than direct connections. This rule in particular has been given additional study and supplemental instructions have been issued to all roads by the Car Service Division at Washington. They, after study with the Committee on Car Service, issued instructions looking toward a further reduction of empty car miles and providing ways and means for prompt return of such cars to owner when the service or home route is circuitous and loading in accordance with car service rules is not practical.

These instructions provide: (1) That exchange arrangements be established by roads either on a mileage basis or a car-for-car basis in disposal of empty cars; (2) that instructions be issued by individual railroads that no car subject to disposal under car service Rule 3 (d) shall be moved in an opposite direction from the home road until authorized by the proper officer; (3) when it is not practical to dispose of such empty foreign cars, reciprocal exchange arrangements, short routing should be arranged if possible without telegraphing car owner but when no such disposition is possible, car owner may be telegraphed and should promptly furnish short route record upon request, up to nearest connecting line to holding road.

As an example, on an indirect connection car, if we

received on an original record a New Haven car from the Union Pacific at Marengo, Wash., loaded destined for Aberdeen, S.D., while car service rules permit us to return this car to Marengo, Wash., it is apparent whoever originated the load complied with the instructions in loading in the direction of owner and while the rule permits return of the car to the delivering line we would take advantage of car service Rule 4 and either short route car to some junction point on our line, enroute to the owners, or by a reciprocal trading arrangement offset with some car of foreign ownership, or would wire the car owner to secure his record from the time car left his rails until it reached ours and then by arranging with some intermediate line, dispose of car without backhauling in home route in a reverse direction from owners.

Rule 4.—Governs the interchange of cars of railroad ownership with steamship and ferry lines.

Rule 5.—Covers the short route of the so-called Rule 3 cars previously mentioned herein, and is mandatory. It also provides for short routing of other empty cars by mutual arrangement between interested lines. This is an important rule and is frequently used in various parts of the country by mutual agreement.

The rule further provides for the service at a reciprocal rate of five cents a mile, plus bridge and terminal arbitraries, with a minimum of 100 miles for each railroad handling the car, the road requesting the service to pay the charges. Settlements for charges accruing under this rule are handled under bill and voucher plan.

Rule 6.—Requires, under certain conditions, return of empty cars to the home road via the junction at which cars were delivered in interchange under load. This rule is also important.

It is interesting in reviewing these rules to note that in the past 35 years many theories have been advanced as to car handling. Prominent among these was the pooling of all classes of equipment as was carried on under the period of federal control. These plans, proposals, or theories have all been given serious and careful study by transportation, mechanical, traffic and Car Service Division officers, with the result that all studies reached the conclusion that the car service rules provided efficient service to the public and leave with the individual railroads the entire responsibilty of providing an adequate car supply.

Please understand, however, that in the application of these rules they must be supervised to secure results. In times of heavy car loading one of the major duties of the Car Service Division at Washington is close supervision as between railroads, supplementing these rules with special orders when necessary, and with success.

Reason for the Average Per Diem Plan

In touching upon the average per diem plan and its history, it is not my purpose to indulge in any criticism, although a recitation of plain facts may make it appear that criticism is intended.

A great many questions have been asked in the past two years as to the cause for the adoption of this plan. I might add when this plan became effective May 1, 1935, there was no change made in car service rules, and the rules adopted in July, 1921, were continued in effect.

The average pier diem plan was adopted because of studies made by the railroads and Car Service Division, principally because of an increase in the ratio of empty to total car miles which was noted after October, 1929, due to the light car loadings.

The plan for payment provided that a check be made for the months January to December, 1932, 1933 and 1934, and when the averages for these months were determined they were applied as the car rental basis for each month in the future, which was very much less on an average than the dollar per day rate previously in effect.

With improved conditions in 1936 and the necessity of again speeding up car movements to take care of traffic, there was a great deal of concern, particularly on the part of western roads as to the longer detention of western cars off line under the average plan than under the straight per diem plan, the western lines in particular being confronted with a lesser supply of cars on line and with increased business, a member road of the Western Association of Railway Executives requested that the subject be docketed for consideration. A committee of western transportation officers including myself, was appointed under proper resolution and after careful study concluded in view of the purpose of the average plan being to save empty car movements, as a result of the light business conditions during the years 1932 to 1934 and that the average plan had accomplished its purpose in slowing up the movement of equipment to owners rails, that action should be taken at once to restore the dollar per diem rate effective July 1, 1937, speeding up the movement of cars as originally intended during periods of increased demand and return of normal conditions.

Average Per Diem Plan Suspended

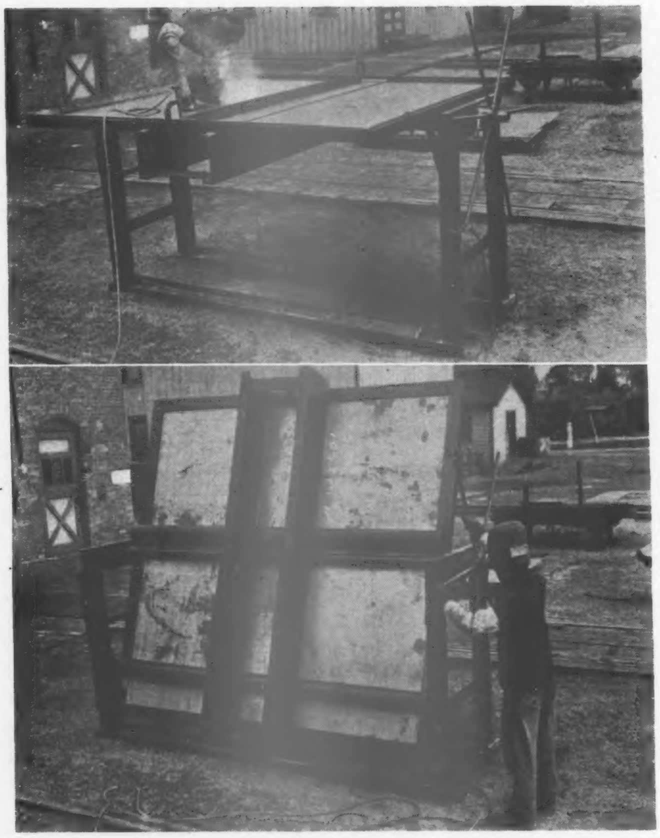
This resolution was approved by the association and transmitted to President Pelley who, in turn, after careful investigation passed the subject to the General Committee who gave the subject further consideration and submitted their recommendations to the association. Further study was continued and at a meeting of the Board of Directors on June 25, 1937, the average per diem plan was suspended for the period July 1, to December 31, 1937, providing, however, that the plan could be continued between member lines if so desired and that is the status of the average plan today. According to the order of the board of directors, the plan will automatically be restored January 1, 1938, unless other action is taken.*

Welding Hopper-Car Slope Sheets

Steel hopper-car slope sheets are being arc-welded into one unit at the welding station of the Delaware & Hudson car shops at Oneonta, N. Y., with the aid of the jig shown in the two accompanying illustrations. The bed of the jig is constructed of channel irons, reinforced with iron strips, and joined by welding. The table of the machine rotates on trunnion bearings and is reinforced by heavy channels so that, despite its own weight and that of the slope sheet being fabricated, it can be rotated with very little manual labor.

These slope sheets are made up of three sections of sheet steel, the jig having been designed so that when the three pieces are laid out side by side they just fill the jig frame. To prevent buckling during the welding operation, the three parts are locked in place by two clamps at each end, and an angle iron running the length of the

* (Since Mr. Brown's paper was delivered, the Board of Directors of the A. A. R. has suspended for another six months the average per diem plan which was in effect from May 1, 1935, until July 1, 1937. On the latter date the plan was suspended until the end of last year, which suspension is now continued until June 30.—Editor.)



Top: Welding three sections of sheet steel into one piece with jig in horizontal position—Bottom: Rotating jig preparatory to welding bottom supports, consisting of sections of reclaimed locomotive flues, in place

middle section which is also clamped down very tightly.

After the three sections are joined by welding, the jig is rotated so that supports can be welded to the bottom of the slope sheet. These supports, by the way, consist of sections of locomotive flues, which, although no longer serviceable in a boiler, will serve this purpose admirably. The finished sheet is picked up by the tractor and taken to the car-construction station where it is lowered into place. As it would be impossible to weld the sheets on the car itself, the jig not only enables the carman to do a job which could not be done without it, but also greatly reduces the time and labor formerly taken to make slope sheets.

Decisions of Arbitration Cases

(The Arbitration Committee of the A.A.R. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Repairs Claimed Excessive and Unwarranted

A Seaboard Air Line steel flat car was given heavy repairs by the Southern on August 22, 1935, at a cost of $155.09, which included $8.45 for truck repairs and $146.64 for renewal of decayed flooring and handling sills.

The Seaboard Air Line contended that the car should have been sent to its home shops, inasmuch as they were located only 46 miles from the point on the Southern where the repairs were made. The owner pointed out that the car, while loaded, had made extensive trips over the Southern lines and after unloading had been moved 32 miles to the Southern shops. Therefore, it contended that that car could have been sent to the home shops as easily as it could have been moved to the Southern shops where repairs were finally made. For these reasons the Southern contended the repairs as made were unnecessary to get the car home, and the costs, excluding those for truck repairs, should be cancelled. However, the Southern pointed out that, after the car was unloaded, part of the flooring was found to be missing and that the entire remaining flooring was found badly decayed and in such condition to make the car unsafe for trainmen. It was decided, by the Southern, that repairs necessary to make the train safe for trainmen could not be made at a reasonable cost and it proceeded to make complete repairs to the car. Inasmuch as the car was repaired in accordance with the original construction of the car and practically all of the cars of the same series were being maintained by the Seaboard Air Line, the Southern contended that the repairs were justified and that no violation of rule 1 was involved.

In a decision rendered on April 8, 1937, the Arbitration Committee stated "The Southern was justified in making repairs to the extent indicated in the agreed statement of facts, at its nearest available repair track, in order to make the car safe for its trainmen. The contention of the Seaboard Air Line is not sustained."—*Case No. 1755, Seaboard Air Line versus Southern.*

Questions and Answers On the AB Brake

Cleaning, Lubricating and Testing (Continued)

260—*Q.—How can the service-portion springs be identified?* A.—By means of the following table:

Description	Piece No.	Outside diam., in.	Wire diam., in.	Free hgt., in.	No. of coils	Material
Graduating valve	93940	0.1607	0.0201	0.656	11	Phosphor-bronze
Piston	94835	0.7910	0.0720	2.328	9	Phosphor-bronze
Return spring	95026	1.8440	0.1562	3.701	6	Steel
By-pass checks	93926	0.8071	0.0571	1.406	4	Phosphor-bronze
Limiting and back-flow checks	94852	0.4730	0.0359	0.922	5	Phosphor-bronze
Limiting - valve diam. spring	95023	1.1440	0.1280	2.984	8	Steel
Release - valve plunger spring	95025	0.9276	0.0985	2.938	9	Steel
Release check - valve spring	93972	0.5571	0.0571	1.469	6	Phosphor-bronze
Release inshot - valve spring	96026	0.4850	0.0475	1.219	8	Steel

261—*Q.—During the assembling operation, how should the slide and graduating valves be lubricated?* A.—The slide and graduating valves and their respective seats should be lubricated with triple-valve dry air-brake graphite; the slide valve spring bearing in the bushing should be lubricated in the same manner.

262—*Q.—What method should be used to apply this lubricant?* A.—A small wooden paddle with one end covered with chamois should be used to apply the graphite.

263—*Q.—How is this accomplished?* A.—By placing a small quantity of graphite on the chamois, rubbing the

seat surfaces until they become a dark copper color; no free graphite must be left on the surfaces.

264—*Q.—What precaution must be observed during this operation?* A.—These parts must be free from oil or grease.

265—*Q.—How should the piston ring and the bushing be lubricated?* A.—Three drops of antifriction oil should be placed in the ring groove, and the ring rotated to distribute the oil. Insert the assembled piston and the slide valve in the bushing to release position, then lubricate the bushing sparingly. After moving the piston back and forth in the bushing several times, any surplus oil on the bushing should be wiped off.

266—*Q.—What must be done previous to the removal of the main piston in the emergency portion?* A.—The upper cover should be removed to permit removal of the diaphragm strut.

267—*Q.—Why is this necessary?* A.—Since the strut holds the slide valve on its seat, removal of the side and the piston would be prevented until the strut has been removed.

268—*Q.—How are the springs behind the emergency vent valve and the inshot valve held in place?* A.—By circular metal retainers having lugs on two opposite sides which engage under lips in the body casting.

269—*Q.—How are the springs and valves removed?* A.—By pressing down the spring retainer and tilting it so that one lug is freed from the lip, permitting removal.

270—*Q.—When cleaning the emergency portion, what method should be followed?* A.—The same as recommended for the service portion.

271—*Q.—In regard to the emergency portion, what exception should be taken when cleaning the chokes?* A.—Three of the chokes are not readily removable; therefore, they should be cleaned in place.

272—*Q.—What three chokes are involved?* A.—The vent-valve piston choke, the diaphragm spill-over choke, and the spill-over check-valve choke.

273—*Q.—How may the springs in the emergency portion be identified?* A.—By means of the following table:

Description	Piece No.	Outside diam., in.	Wire diam., in.	Free hgt., in.	No. of coils	Material
Accelerated emergency release check valve....	94952	0.7440	0.0720	1.4063	4	Phosphor-bronze
Spill-over check valve	94581	0.4790	0.0285	1.1000	5	Phosphor-bronze
Strut - diaphragm spring	94839	0.6891	0.0641	1.1250	4	Phosphor-bronze
Vent-valve spring.	81643	1.3750	0.1250	2.7188	6	Steel
Inshot piston spring	95032	1.1920	0.0985	2.6406	5½	Steel
Inshot check-valve spring	94836	0.5216	0.0508	1.7188	12	Phosphor-bronze
Emergency piston spring	94835	0.7910	0.0720	2.3280	9	Phosphor-bronze
Graduating valve spring	93940	0.1607	0.0201	0.6563	11	Phosphor-bronze
Return spring ...	95026	1.8440	0.1562	3.7010	6	Steel
Piston inner spring	95024	1.2040	0.1416	2.7500	7	Steel
Piston outer spring	95027	1.9410	0.2070	3.1560	5	Steel

274—*Q.—How should the parts of the emergency portion be lubricated?* A.—The same as the service portion. The vent-valve piston and accelerated-release piston should be lubricated in the same manner as the main piston.

Brake Cylinders

275.—*Q.—How should the brake cylinder be dismantled for cleaning?* A.—It should be dismantled by removing the non-pressure head, thus permitting the removal of the piston assembly.

276—*Q.—How can the cylinder cup be removed?* A.—The cup is not held in place by a follower, but fits over a bead in the piston head; therefore, the removal of the cup is effected by snapping it over the aforementioned bead.

277—*Q.—What attention should be given the packing?* A.—It should be cleaned and inspected carefully. If there are any deep scratches or cracks on the bearing surface or if the packing cup is worn too much to hold a proper bearing, it should be replaced.

* * *

The 20-car UC brake-equipment-test rack of the New York Air Brake Company

At the left front of the rack is the No. 8 distributing valve and, left to right, the No. 6ET automatic and independent brake valves, the L-8-PA pedestal brake valve and the automatic and independent brake valves of the LT equipment. The universal valves are near the floor under the brake cylinders. From the catwalk, angle cocks can be operated and connections made between cars.

Among the Clubs and Associations

Car Department Association of St. Louis Organized

The Car Department Association of St. Louis has been organized in St. Louis, Mo., to succeed the Car Foremen's Association. Officers elected for the ensuing year are: president, C. R. Wiegman, chief interchange inspector for the St. Louis & East St. Louis Joint Inspection Bureau; first vice-president, W. P. Elliott, general car foreman of the Terminal Railroad Association; second vice-president, F. E. Cheshire, general car inspector of the Missouri Pacific; third vice-president George A. Marx, general car foreman of the Wabash; secretary, J. J. Sheehan, chief clerk to the master car builder of the Missouri Pacific; and treasurer, F. O. Correll, car foreman for the St. Louis Southwestern.

The regular monthly meeting of the association will be held on the third Tuesday of each month at the Statler hotel.

Car Officers' Committees Are Appointed

After a lapse of six years the Car Department Officers' Association held a two-day annual meeting at Chicago last fall, which was sufficiently promising that an attempt is now being made to revive and reorganize the association's activities as a valuable supplement to the work of the A.A.R. Mechanical Division. In line with this objective, President K. F. Nystrom, mechanical assistant to the chief operating officer, Chicago, Milwaukee, St. Paul & Pacific, has recently announced the appointment of the following standing committees with specific duties and personnel as indicated below:

General Committee—To make the association function effectively in improving the knowledge and acquaintance of individual members and promoting greater efficiency in railway car departments:

E. J. Robertson (chairman), superintendent car department, M. St. P. & S. S. M., Minneapolis, Minn.
C. J. Nelson, superintendent of interchange, Chicago Car Interchange Bureau, Chicago.
W. E. Dunham, general superintendent car department, C. & N. W., Chicago.
J. S. Acworth, superintendent of equipment, General American Transportation Corporation, Chicago.
F. L. Kartheiser, chief clerk, mechanical, C. B. & Q., Chicago.
E. L. Woodward, western editor, Railway Mechanical Engineer, Chicago.

Car Construction and Maintenance—To discuss the latest approved A.A.R. recommendations for passenger- and freight-car design and make recommendations for improved methods in connection with car construction and maintenance:

J. McMullen (chairman), superintendent car department, Erie, Cleveland, Ohio.
C. Claudy, master car builder, G. T. W., Battle Creek, Mich.
W. A. Bender, master car builder, Alton, Chicago.
J. S. Acworth, superintendent of equipment, General American Transportation Corporation, Chicago.
J. E. Keegan, chief car inspector, Penna., Chicago.

Shop Operation, Facilities and Tools—To make recommendations for the economical operation of freight- and passenger-car shops, including improved shop facilities, such as buildings, cranes, machinery, etc:

J. A. Deppe (chairman), superintendent car department, C. M. St. P. & P., Milwaukee, Wis.
J. H. Gimpel, assistant superintendent car department, Wabash, Decatur, Ill.
M. F. Covert, general superintendent of equipment, General American Transportation Corporation, Chicago.
H. S. Keppelman, superintendent car department, Reading, Reading, Pa.
P. B. Rogers, shop superintendent, A. T. & S. F., Chicago.

Passenger Train Car Terminal Handling—To make recommendations for the economical operation of passenger-car yards, including car cleaning maintenance of air conditioning equipment, etc:

G. R. Andersen (chairman), district master car builder, C. & N. W., Chicago.
F. E. Cheshire, general car inspector, M. P., St. Louis, Mo.
J. M. Thommen, general car inspector, Penna., Chicago.
C. Houser, general car foreman, N. Y. C., Chicago.
E. J. Hollohan, general car foreman, I. C., Chicago.

Lubricants and Lubrication—To discuss the latest A.A.R. rules covering lubrication and make recommendations for further improvement in the lubrication of freight and passenger cars:

L. R. Wink (chairman), assistant superintendent car department, C. & N. W., Chicago.
F. Maddox, superintendent car department, C. & O., Richmond, Va.
P. P. Barthelemy, master car builder, G. N., St. Paul, Minn.
F. B. Lewis, general car inspector, U. P., Cheyenne, Wyo.
R. Knorr, supervisor car repairs, Erie, Cleveland, Ohio.

Freight Car Inspection for Commodity Loading—To make recommendations for the inspection and selection of cars for commodity loading; cleaning freight cars, eliminating oil spots, odors, etc.:

F. G. Moody (chairman), master car builder, N. P., St. Paul, Minn.
F. J. Swanson, general car department supervisor, C. M. St. P. & P., St. Paul, Minn.
E. S. Smith, master car builder, F. E. C., St. Augustine, Fla.
P. J. Hogan, supervisor car inspection, N. Y. N. H. & H., New Haven, Conn.
W. A. Emerson, master car builder, E. J. & E., Joliet, Ill.

Interchange Rules—To report on car inspection and interchange problems, reviewing the latest rule changes approved by the A.A.R. and recommending desirable further revisions:

M. R. Fitzgerald (chairman), general car inspector, C. & E. I., Danville, Ill.
C. J. Nelson, superintendent of interchange, Chicago Car Interchange Bureau, Chicago.
J. E. Mehan, assistant to superintendent car department, C. M. St. P. & P., Milwaukee, Wis.
H. E. Wagner, general car foreman, M. P., Dupe, Ill.
C. Houser, general car foreman, N. Y. C., Chicago.

Loading Rules—To discuss the latest approved changes in A.A.R. loading rules and make recommendations for loading methods and other details essential to better service:

C. J. Nelson (chairman), superintendent of interchange, Chicago Car Interchange Bureau, Chicago.
G. R. Andersen, district master car builder, C. & N. W., Chicago.
H. H. Golden, supervisor, A. A. R. Interchange and Accounting, L. & N., Louisville, Ky.
H. T. DeVore, chief int. inspector, Youngstown Car Inspection Association, Youngstown, Ohio.
Wm. Govert, master car builder, E. J. & E., Cary, Ind.

Car Repair Billing—To analyze the latest approved changes in A.A.R. billing rules and make recommendations for further improvements in these rules:

D. E. Bell (chairman), A. A. R. instructor, C. N., Winnipeg, Man.
B. J. Jamison, assistant supervisor car insp., Southern, Birmingham, Ala.
E. S. Swift, chief A. A. R. clerk, Wabash, Decatur, Ill.
W. E. Henley, traveling mechanical inspector, I. C., Chicago.
W. J. Burns, mechanical inspector, General American Transportation Corporation, Chicago.
American Transportation Corporation, Chicago.

Equipment Painting—To study general painting problems and report on improved methods of painting freight- and passenger-car equipment:

L. B. Jenson (chairman), passenger shop superintendent, C. M. St. P. & P., Milwaukee, Wis.
M. Thierry, foreman painter, N. & W., Roanoke, Va.
D. C. Sherwood, foreman painter, N. Y. C., West Albany, N. Y.
C. E. Bergquist, foreman car painter, C. & N. W., Chicago.
J. F. Monger, shop superintendent, I. C., Chicago.
R. B. Batcheler, foreman car painter, Wabash, Decatur, Ill.
J. McDowell, foreman paint shop, C. R. I. & P., Chicago.
W. Schwenk, foreman painter, M. P., Sedalia, Mo.
C. Swing, painter foreman, Pullman-Standard Car Manufacturing Company, Chicago.
D. Richmann, paint foreman, Pullman Company, Chicago.
M. P. Neuberger, foreman painter, M. St. P. & S. S. M., Shoreham, Minn.
Robert Woods, master painter, G. T. W., Port Huron, Mich.
W. Adolf, master painter, U. P., Omaha, Neb.
J. Pritchard, master painter, A. T. & S. F., Topeka, Kan.

Western Metal Congress

The Western Sections of a number of national technical societies, including the American Society of Mechanical Engineers, the American Welding Society and the American Society for Testing Materials, are co-operating in the Western Metal Congress and Western Metal Exposition to be held at Los Angeles, Calif., March 21, 22, 23, 24 and 25. At a session on Monday morning, March 21, at the Hotel Biltmore, "The Fabrication and Application of Stainless Steels Containing 18 Per Cent Chromium and Over" will be discussed by Dr. V. N. Krivobok, associate director of research, Allegheny Steel Company, Brackenridge, Pa. In the afternoon, at the Pan-Pacific Auditorium, A. F. Stuebing, railroad mechanical engineer, United States Steel Corporation, New York, will present a paper on "High-Tensile Structural Steels

(*Continued on next left-hand page*)

Metal Congress (Continued)

in Transportation." On Thursday morning, March 24, at the Biltmore Hotel, two other papers of interest to the railroad industry will be presented by J. P. Gill, chief metallurgist, Vanadium Alloys Steel Corp., Latrobe, Pa.: "Carbon and Low-Alloy Tool Steels" and "High Speed and Highly Alloyed Tool Steels."

A series of five educational lectures under the title "Fundamentals of Ferrous Metallurgy" will be given at evening sessions at the Pan-Pacific Auditorium by Dr. A. Allan Bates, manager of the chemical and metallurgical department, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

Club Papers

Railroad Labor Relations Today

NEW YORK RAILROAD CLUB.—Meeting held at New York, February 18, 1938. Otto S. Beyer, chairman of the National Mediation Board, discussed the opportunity which railroad labor has to exercise a constructive influence on the future progress of the railroad industry. ¶"We all realize," said Mr. Beyer, "that the railroads are now confronted with problems whose solution challenges the resourcefulness and statesmanship of both our managers and employees . . . It is clear that unless ways are found to co-operate with them [employees] constructively, railroad service stands to suffer and railroad employment to decline." ¶Mr. Beyer devoted a considerable part of his address to emphasizing the possibilities for better organized co-operation between the employees and the managements in fields beyond the direct performance of duties for which the employees are paid. ¶Railroad employees, he said, are in an exceptional position to determine how the myriad detailed processes of operation can best be performed and to devise new and better ways of doing them. "Given a genuine inducement to improve these processes," said Mr. Beyer, "an army of a million and a quarter individuals is available to make innumerable contributions by way of bettering the day-by-day performance of our railroads." He also pointed out the strategic position of railroad employees with respect to the public relations of the industry. The value of the joint-conference method of relations between labor and management to matters of common interest other than purely labor questions, Mr. Beyer thought, would develop only if the employees have the same freedom in the choice of representatives established by the Railway Labor Act for the purposes of collective bargaining.

Usefulness, The Supreme Test

CENTRAL RAILWAY CLUB.—In an address before the Central Railway Club of Buffalo, N. Y., on February 10, Dr. C. S. Duncan, economist, Association of American Railroads, introduced his remarks by the statement that two factors had made a profound impression; namely, the essential necessity for an adequate, efficient transport system and the overwhelming efficiency of railroads as compared with competitive forms of transport. He paid tribute to the ability of the railroads to carry on efficiently, under regulation, in competition with subsidized carriers, not so regulated. ¶Looking somewhat into the future, Mr. Duncan raised the questions as to what tests must ultimately determine the relative importance to public welfare of the various transport agencies, and upon what basis are we to determine what agencies are to be maintained and what ones are to be neglected? He said that the correct answer to these inquiries will provide the basis for a sound national transportation policy. In developing his remarks, Mr. Duncan mentioned certain methods that have been used to measure the relative usefulness of transport agencies: First, The historical method which, in essence, means that which is newest is best. Second, the relative traffic method, meaning that the agency carrying the greatest number of units is the most useful. Third, the relative tariff charge for service. This method is based on the theory that the lower the direct charge the more superior the agency. Fourth, the cost and service test. Fifth, the "full community service" method, based upon a theory that the true measure of relative usefulness of a transport facility is its ability to afford complete service to the whole needs of a community or the entire country. ¶In concluding his remarks Mr. Duncan said, in part, "I care not what test is applied, or with what weight attached, if all agencies must meet them on an even-handed basis. The community that can support every known means of transportation is unquestionably entitled to them all," provided it does support them and does not pass a part of the cost on to the public in the form of taxes. ¶If this primary principle were adopted, I think everything else would follow simply, logically and inevitably. Any test of relative usefulness for any agency will require careful consideration for all. We have never had that heretofore.

DIRECTORY

The following list gives names of secretaries, dates of next regular meetings, and places of meetings of mechanical associations and railroad clubs:

AIR-BRAKE ASSOCIATION.—R. P. Ives, Westinghouse Air Brake Company, 350 Fifth avenue, New York.

ALLIED RAILWAY SUPPLY ASSOCIATION.—J. F. Gettrust, 1108 New Post Office Bldg., Chicago.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—G. G. Macina, 11402 Calumet avenue, Chicago.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—C. E. Davies, 29 West Thirty-ninth street, New York.

RAILROAD DIVISION.—Marion B. Richardson, P. O. Box 205, Livingston, N. J.

MACHINE SHOP PRACTICE DIVISION.—J. R. Weaver, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

MATERIALS HANDLING DIVISION. — F. J. Shepard, Jr., Lewis-Shepard Co., Watertown Station, Boston, Mass.

OIL AND GAS POWER DIVISION. — M. J. Reed, 2 West Forty-fifth street, New York.

FUELS DIVISION.—A. R. Mumford, N. Y. Steam Corp., 130 E. Fifteenth st., New York.

ASSOCIATION OF AMERICAN RAILROADS. — J. M. Symes, vice-president operations and maintenance department, Transportation Building, Washington, D. C.

OPERATING SECTION.—J. C. Caviston, 30 Vesey street, New York.

MECHANICAL DIVISION.—V. R. Hawthorne, 59 East Van Buren street, Chicago.

COMMITTEE ON RESEARCH.—William J. Cantley, mechanical engineer Lehigh Valley, Bethlehem, Pa.

PURCHASES AND STORES DIVISION.—W. J. Farrell, 30 Vesey street, New York.

MOTOR TRANSPORT DIVISION — George M. Campbell, Transportation Building, Washington, D. C.

CANADIAN RAILWAY CLUB.—C. R. Crook, 2271 Wilson avenue, Montreal, Que. Regular meetings, second Monday of each month, except in June, July and August, at Windsor Hotel, Montreal, Que.

CAR DEPARTMENT ASSOCIATION OF ST. LOUIS.—J. J. Sheehan, 1101 Missouri Pacific Bldg., St. Louis, Mo. Regular monthly meetings third Tuesday of each month, except June, July and August, Statler Hotel, St. Louis, Mo.

CAR DEPARTMENT OFFICERS' ASSOCIATION.—Frank Kartheiser, chief clerk, Mechanical Dept., C. B. & Q., Chicago.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—G. K. Oliver, 2514 West Fifty-fifth street, Chicago. Regular meetings, second Monday in each month, except June, July and August, La Salle Hotel, Chicago.

CAR FOREMEN'S ASSOCIATION OF OMAHA, COUNCIL BLUFFS AND SOUTH OMAHA INTERCHANGE.—H. E. Moran, Chicago Great Western, Council Bluffs, Ia. Regular meetings, second Thursday of each month at 1:15 p. m.

CENTRAL RAILWAY CLUB OF BUFFALO.—Mrs. M. D. Reed, Room 1817, Hotel Statler, Buffalo, N. Y. Regular meetings, second Thursday each month, except June, July and August, at Hotel Statler, Buffalo.

EASTERN CAR FOREMEN'S ASSOCIATION.—E. L. Brown, care of the Baltimore & Ohio, St. George, Staten Island, N. Y. Regular meetings, fourth Friday of each month, except June, July, August and September.

INDIANAPOLIS CAR INSPECTION ASSOCIATION.—R. A. Singleton, 822 Big Four Building, Indianapolis, Ind. Regular meetings, first Monday of each month, except July, August and September, at Hotel Severin, Indianapolis, at 7 p. m.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—See Railway Fuel and Traveling Engineers' Association.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—F. T. James (President), general foreman, D. L. & W., Kingsland, N. J.

INTERNATIONAL RAILWAY MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 2347 Clark avenue, Detroit, Mich.

MASTER BOILER MAKERS' ASSOCIATION.—A. F. Stiglmeier, secretary, 29 Parkwood street, Albany, N. Y.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic avenue, Boston, Mass. Regular meetings, second Tuesday in each month, except June, July, August and September, at Hotel Touraine, Boston.

NEW YORK RAILROAD CLUB.—D. W. Pye, Room 527, 30 Church street, New York. Meetings, third Friday in each month, except June, July, August and September, at 29 West Thirty-ninth street, New York.

NORTHWEST CAR MEN'S ASSOCIATION. — E. N. Myers, chief interchange inspector, Minnesota Transfer Railway, St. Paul, Minn. Meetings, first Monday each month, except June, July and August, at Midway Club rooms, University and Prior avenue, St. Paul.

PACIFIC RAILWAY CLUB.—William S. Wollner, P. O. Box 3275, San Francsico, Cal. Regular meetings, second Thursday of each month in San Francisco and Oakland, Calif., alternately—June in Los Angeles and October in Sacramento.

RAILWAY CLUB OF GREENVILLE. — J. Howard Waite, 43 Chambers avenue, Greenville, Pa. Regular meetings, third Thursday in month, except June, July and August.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 1941 Oliver Building, Pittsburgh, Pa. Regular meetings, fourth Thursday in month, except June, July and August, Fort Pitt Hotel, Pittsburgh, Pa.

RAILWAY FIRE PROTECTION ASSOCIATION.—P. A. Bissell, 40 Broad street, Boston, Mass.

RAILWAY FUEL AND TRAVELING ENGINEERS' ASSOCIATION.—T. Duff Smith, 1255 Old Colony building, Chicago.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.—J. D. Conway, 1941 Oliver Building, Pittsburgh, Pa. Meets with Mechanical Division and Purchases and Stores Division, Association of American Railroads.

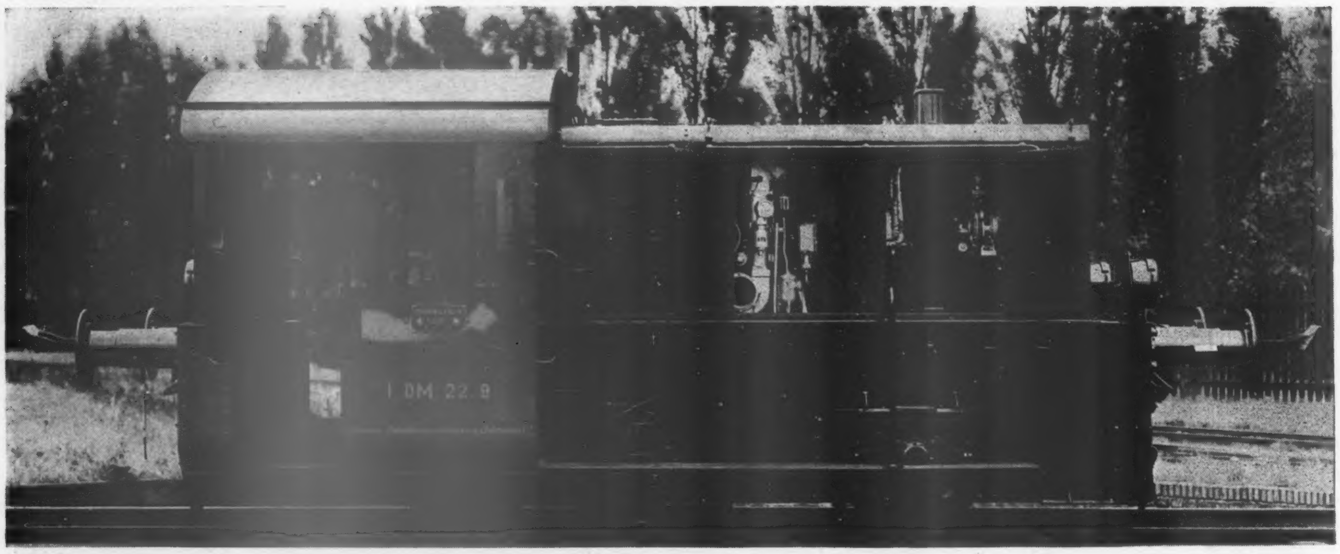
SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—A. T. Miller, P. O. Box 1205, Atlanta, Ga. Regular meetings, third Thursday in January, March, May, July and September. Annual meeting, third Thursday in November, Ansley Hotel, Atlanta, Ga.

TORONTO RAILWAY CLUB.—D. M. George, Box 8, Terminal A, Toronto, Ont. Meetings, fourth Monday of each month, except June, July and August, at Royal York Hotel, Toronto, Ont.

TRAVELING ENGINEERS' ASSOCIATION.—See Railway Fuel and Traveling Engineers' Association.

WESTERN RAILWAY CLUB.—C. L. Emerson, executive secretary, 822 Straus Building, Chicago. Regular meetings, third Monday in each month, except June, July, Aug. and Sept.

(Turn to next left-hand page)



Henschel steam switching locomotive of the Besler type—Weight, 37,250 lb.; boiler pressure, 1,140 lb.; steam temperature, about 700 deg.; maximum speed, 37 m.p.h.

NEWS

Train-Handling Conference

THE Kansas State Board for Vocational Education is planning a train-handling and locomotive-devices conference, to be held in the Chamber of Commerce Building, Kansas City, Kan., March 29 to April 1, inclusive. The conference leader will be C. M. Drennan, Kansas State Teachers College, Pittsburgh, Kan.

G. E. Puts Turbo-Electric Unit Through Its Paces

THE General Electric Company, which is building a twin-unit steam-electric locomotive, powered primarily by two oil-fired 2,500-hp. "steamotive" units, for service on the Union Pacific, has for some weeks been carrying on track tests with one completed unit at its Erie, Pa. plant.

Equipment Depreciation Orders

THE Interstate Commerce Commission has issued additional sub-orders and modifications of previous sub-orders in No. 15100, Depreciation Charges of Steam Railroad Companies, prescribing depreciation rates for equipment of eight roads, including the Chesapeake & Ohio, the Bessemer & Lake Erie and the Chicago & North Western. The composite percentages, which are not prescribed rates, range from 2.71 per cent for the State Belt of California to 5.72 per cent for the Wyoming.

The C. & O. composite percentage of 4.29 is derived from the following prescribed rates: Steam locomotives, 3.82 per cent; freight-train cars, 4.52 per cent; passenger-train cars, 3.21 per cent; floating equipment, 3.25 per cent; work equipment, 4.67 per cent; miscellaneous equipment, 17.56 per cent. The B. & L. E.'s 3.36 per cent composite figure comes from prescribed rates as follows: Steam locomotives (owned), 4.05 per cent; steam locomotives (leased), 3.09 per cent; other locomotives 4.8 per cent; freight-train cars (owned), 3.19 per cent; freight-train cars (leased), 3.06 per cent; passenger-train cars, 3.5 per cent; work equipment (owned), 3.78 per cent; work equipment (leased), 2.77 per cent; miscellaneous equipment, 14.75 per cent. The sub-order, which modifies a previous one with respect to the C. & N. W., was issued to provide separate rates for equipment in streamlined trains as follows: Locomotives other than steam, 6.4 per cent; passenger-train cars, 6.4 per cent.

Proposed Changes in Explosives Rules Issued

THE Bureau of Explosives of the Interstate Commerce Commission has issued a first proof of its proposed general revision of I. C. C. regulations for the transportation of explosives and other dangerous articles by freight and specifications for shipping containers. In a preface signed by W. S. Topping, chief inspector of the bureau, it is stated that the general revision includes re-arrangement of the rules, elimination of duplication of rules, and a simplification of shipping requirements.

Mr. Topping requests that prompt consideration of the revision be given by interested parties and asks that additions, changes or modifications be submitted to the Bureau of Explosives, 30 Vesey Street, New York, on or before March 15.

Unit Fuel Costs Increase

IN an effort to concentrate attention on rising fuel costs and the necessity of redoubled efforts to conserve fuel, the Railway Fuel & Traveling Engineers' Association has developed the table of comparative performances and costs given below, based on figures compiled by the Interstate Commerce Commission Bureau of Statistics. The figures are for freight

(Continued on next left-hand page)

Fuel Performances and Costs in Freight and Passenger Road Service, Class I Railways

	December 1937	December 1936	Per cent increase or decrease, 1937, compared with 1936
Coal per 1,000 gross ton-miles, lb. (Including locomotive and tender)	128.0	127.0	+0.79
Fuel cost per 1,000 gross ton-miles, cents (Including locomotive and tender)	17.80	16.40	+8.54
Coal per passenger train car-miles, lb.	16.0	15.9	+0.63
Fuel cost per passenger train car-mile, cents	2.22	2.03	+9.36
Average cost of fuel per equated net ton (Coal equivalent)	$2.78	$2.58	+7.75
	1937 Year	1936 Year	
Coal per 1,000 gross ton-miles, lb. (Including locomotive and tender)	117.0	119.0	−1.68
Fuel cost per 1,000 gross ton-miles, cents (Including locomotive and tender)	15.85	15.47	+2.46
Coal per passenger train car-mile, lb.	15.1	15.3	−1.31
Fuel cost per passenger train car-mile, cents	2.04	1.98	+3.03
Average cost of fuel per equated net ton (Coal equivalent)	$2.72	$2.59	+5.02

and passenger road service on Class I carrier (excluding switching and terminal companies) and show an increase of 8.54 per cent in fuel cost per 1,000 gross ton-miles and 9.36 per cent per passenger train car-mile in December, 1937, as compared with December, 1936. Figures are also given for the year 1937, as compared with 1936, and show that in spite of decreased unit fuel consumption in both freight and passenger service, unit fuel costs have increased 2.46 and 3.03 per cent, respectively.

According to a carefully-developed estimate, the present minimum prices for locomotive coal prescribed by the National Bituminous Coal Commission will increase the railroad fuel bill for 1938 to the extent of $21,000,000 above the amount of approximately $275,000,000 spent in 1937, or an increase of 7.6 per cent.

Improvement Programs

LEHIGH VALLEY.—The Lehigh Valley has asked the Interstate Commerce Commission for permission to borrow $778,000 from the Reconstruction Finance Corporation for repairs and for the purchase of new rolling stock. The company needs to repair 1,460 steel coal cars and would re-employ 300 men to carry out this work at its Sayre, Pa., and Packerton shops.

CHICAGO & NORTH WESTERN.—The C. & N. W. is considering re-equipping its "400" (which operates between Chicago and the Twin Cities) with lightweight, streamline equipment. Inquiries have been issued for 12 passenger cars and three locomotives. The request for bids covers conventional steam locomotives, Diesel-electric locomotives, and steam turbine-electric locomotives and lightweight cars.

CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC.—The district court at Chicago has authorized trustees of the C. M. St. P. & P. to seek Interstate Commerce Commission permission to issue $2,235,000 in equipment trust certificates to finance $3,210,922 of new equipment. The equipment includes four high-speed steam locomotives, 55 passenger cars and 464 fifty-ton flat cars, the car equipment to be constructed in company shops when the present program of building 1,000 gondola cars is completed in April. Some of the new passenger cars will be used to equip additional sections of the Hiawatha, while others will be used to replace obsolete equipment. On December 31, 1935, according to the petition, the road had 958 passenger cars with an average age of 25 years. The petition indicated that the road plans to use the new locomotives on runs between Chicago and the Twin Cities because locomotives now operating between these cities are required to run at higher speed than they were designed to make.

UNION PACIFIC.—Resumption of a $9,000,000 car-building program has been announced by W. M. Jeffers, president of the Union Pacific, on February 16. In making the announcement Mr. Jeffers said "recessions do not last forever. While our revenues have shown a drastic decline during the past ninety days and the outlook for the near future is not favorable, we have decided to disregard the immediate situation and to continue our program in anticipation of future improvement in business conditions . . . During the past two years we have carried on this car-building program in our own shops in the West employing our own skilled labor in order to stabilize just as far as practicable employment conditions on our lines."

Construction of 2,600 cars under an appropriation of $9,000,000 was begun in October, 1937, and of this number 1,700 cars remain to be completed. Resumption of construction will provide employment till next summer for the 400 employees who have just recently returned to work at the Omaha, Neb., Grand Island and Portland, Ore., shops.

MISSOURI PACIFIC.—The expenditure of $7,621,153 for improvement to right-of-way and rolling stock of the Missouri Pacific and six subsidiaries has been authorized by the federal district court at St. Louis. Of this amount, $7,008,973 will be expended on Missouri Pacific property. Of the latter amount $1,118,040 is for equipment and shop improvement. Among the improvements included in the schedule are those at the enginehouse and shops in St. Louis to cost $103,840, the construction of bridges, grade crossings, stations and shop and the repair of locomotives, passenger and freight cars.

In addition to this amount, the district court later approved a budget of $1,769,660 for improvements this year on the lines of the International-Great Northern and the New Orleans, Texas & Mexico.

NEW YORK, NEW HAVEN & HARTFORD.—The New Haven has received permission of the United States District Court to remodel into modern coaches 50 cars formerly used on the New York, Westchester & Boston, at a total cost of $700,000 and the overhauling and modernizing of 100 of the New Haven's old standard steel coaches at a cost of $553,000.

Electrical equipment which was required for operation of the Westchester cars, which are of the multiple-unit type, will be removed, the center doors will be taken out and replaced with wall sections and windows, sliding end-doors will be changed to swinging doors, baggage racks will be installed, the cars will be equipped with a modern steam-heating system, and they will be furnished with the latest type of comfortable seats.

The 100 standard steel cars also will have all the old type seats replaced with present-day more comfortable seats, and modern lighting, new steam piping with thermostatic heat control, and new floors will be installed.

These remodelled cars will be in addition to the 50 new streamline coaches which the court has authorized and which will bring to a total of 200 the number of that type of coach owned by the New Haven.

The court has also authorized the purchase of 10 Diesel-electric switching locomotives.

Transport Equipment Obtained Through P. W. A.

CLOSE to $100,000,000 worth of new transportation equipment is in use throughout the nation as the result of the Public

(*Continued on next left hand page*)

New Equipment Orders and Inquiries Announced Since the Closing of the February Issue

LOCOMOTIVE ORDERS

Road	No. of Locos.	Type of Loco.	Builder
Grand Trunk Western...	6	4-8-4 streamline	Lima Locomotive Works
Maine Central	1*	250-hp. gas-mech.	Plymouth Locomotive Works
New York, New Haven & Hartford	10	600-hp. Diesel-electric	American Locomotive Co.

LOCOMOTIVE INQUIRIES

Road	No. of Locos.	Type of Loco.	Builder
Chicago & North Western	..	Steam	....
	..	Diesel-electric	....
	..	Steam-turbine	....
	..	Turbine mechanical	....

FREIGHT-CAR ORDERS

Road	No. of Cars	Type of Car	Builder
Canadian National	700	Box	Eastern Car Co.
	700	Box	Nat'l Steel Car Corp.
	600	Box	Canadian Car & Fdry. Co
Chicago, Burlington & Quincy	100	Rodger ballast	American Car and Foundry Co.
Paulista Railway of Brazil	125	Gondola	Pullman-Standard Car Export Corporation
	125	Flat	Pullman-Standard Car Export Corporation
	95	Underframes	Pullman-Standard Car Export Corporation

FREIGHT-CAR INQUIRIES

Road	No. of Cars	Type of Car	Builder
Bangor & Aroostook.....	500	40-ton box	....
	100	70-ton hopper	....
	50	50-ton rack	....

PASSENGER-CAR ORDERS

Road	No. of Cars	Type of Car	Builder
Canadian National	6†	Dining	Canadian Car and Foundry Co., Ltd.
	10†	Cafe-sleeper	Canadian Car and Foundry Co., Ltd.
New York, New Haven & Hartford	50‡	Lightweight	Pullman-Standard Car Manufacturing Co.

* M-L-8 type, 30-ton locomotive with 8 cylinders, 6¼ in. by 7 in., equipped with a LeRoy engine, for service at Lewiston, Me.

† All of the cars are to be air-conditioned and, it is expected, will be delivered next June. The cafe-sleeping cars, designed by the company's engineers and architects, are a departure from the usual type of equipment. Each car will consist of 8 sections, a double bedroom, smoking room and ladies' dressing room, with a cafe at one end accommodating 16 guests. The kitchen and pantry of the dining cars will be somewhat smaller than the regulation diner; they will each have accommodation for 40 persons, which is 4 more than those now in use, and will be 20,000 lb. lighter than the old type, being constructed of alloy steel.

‡ The court has granted permission to this road to rebuild 100 of its own coaches and 50 of the coaches formerly used on the New York, Westchester and Boston.

Works Administration program, a report of the Bureau of Labor Statistics shows.

"The equipment," the report says, "ranges from motorcycles to freight cars, and embraces transportation for land, water and air."

Total purchases of transportation equipment financed by the P. W. A. were put at $90,032,332. Railway equipment purchases were thus financed "in an effort to revive employment in railroad equipment lines. As a result, out of the total of $1,708,685,535 spent for materials throughout the whole P. W. A. construction program, $38,839,968 went for railway freight cars. Passenger cars to the extent of $8,893,300 were purchased and $18,671,303 was spent for locomotives."

Equipment Installed in 1937

CLASS I railroads in 1937 installed 75,058 new freight cars in service, according to the Association of American Railroads. At the same time, reports showed a sharp drop in the number of new freight cars on order on January 1.

The number of new freight cars installed in 1937 was the largest number placed in service in any one year since 1930, "owing to the large orders for new equipment which were awarded early in 1937 in anticipation of heavy freight traffic." The decrease in such orders in the latter months of the year is attributed to "the financial condition of the railroads and the reduction in traffic that took place."

The 1937 freight car installations represent an increrse of 31,117 compared with 1936 and an increase of 66,155 compared with 1935. The 1937 total included 37,663 cars, 30,022 box cars, 4,227 refrigerator cars, 1,993 flat cars, 712 stock cars and 441 miscellaneous cars.

Class I roads also put in service 373 new steam locomotives in 1937, also the greatest number for any year since 1930. In 1936 new steam locomotives put in service totaled 87 and in 1935, 40; new electric and Diesel locomotives totaled 77 compared with 34 in 1936 and 102 in 1935.

New freight cars on order on January 1 totaled 7,947 compared with 12,566 on December 1, 1937, and 25,592 on January 1, 1937. New steam locomotives on order on January 1, totaled 131 compared with 156 on December 1, 1937, and 297 on January 1, 1937. New electric and Diesel locomotives on order at the beginning of this year totaled 30 contrasted with 40 ordered on December 1, last, and seven orders on hand at the beginning of 1937.

New freight cars and locomotives leased or otherwise acquired are not included in the above figures.

"Soda Ash Johnny" Passes Away

JOHN M. HORAN of the Chicago, Milwaukee, St. Paul & Pacific, who died on Friday, February 4, at the age of 100 years and 12 days, has established a record for continuous service with a railroad which it will be difficult to reach or surpass. He remained in service until his death, and on the occasion of his one-hundredth birthday, January 23, 1938, was given a party in a dining car in the Milwaukee shops, the accompanying photograph having been taken on that day.

Mr. Horan, or "Soda Ash Johnny" as he was more familiarly called, was born in Burlington, Vt., January 23, 1838, but grew up from childhood in Milwaukee. He entered the service of the Milwaukee & Mississippi Railroad, April 17, 1855. Wood was used for locomotive fuel and his first job was to pile the prepared wood in racks with capacities of one-quarter cord, one-half cord, and one cord, this being the means of measuring the amount of fuel issued to the locomotives. He was ambitious to become a mechanic and served a machinist apprenticeship on the Milwaukee & Prairie du Chien Railroad, the successor to the Milwaukee & Mississippi. Later he became a locomotive fireman and then was promoted to engineer. When the Dakota Southern Railroad was purchased by the Chicago, Milwaukee & St. Paul, Mr. Horan was sent to Yankton, S. D., as general foreman. Water conditions in that territory were bad and Mr. Horan was unusually successful in developing a treatment of the water used in locomotive boilers. Because of this he was assigned to follow up boiler feedwater conditions and the washing and care of boilers on the entire system, and was active in that occupation until his death.

John M. Horan on his one-hundredth birthday

Union Pacific Locomotives—A Correction

LEWIS special staybolt iron, furnished by Joseph T. Ryerson & Son, Inc., Chicago, was used for the flexible and rigid stays on six and five locomotives, respectively, of the 4-8-4 type recently delivered to the Union Pacific by the American Locomotive Company. The Lewis Bolt & Nut Co. is incorrectly given in the list of materials on page 49 of the February issue.

Supply Trade Notes

THE THOMAS GRATE BAR COMPANY, Birmingham, Ala., has changed its name to Thomas Foundries, Inc.

◆

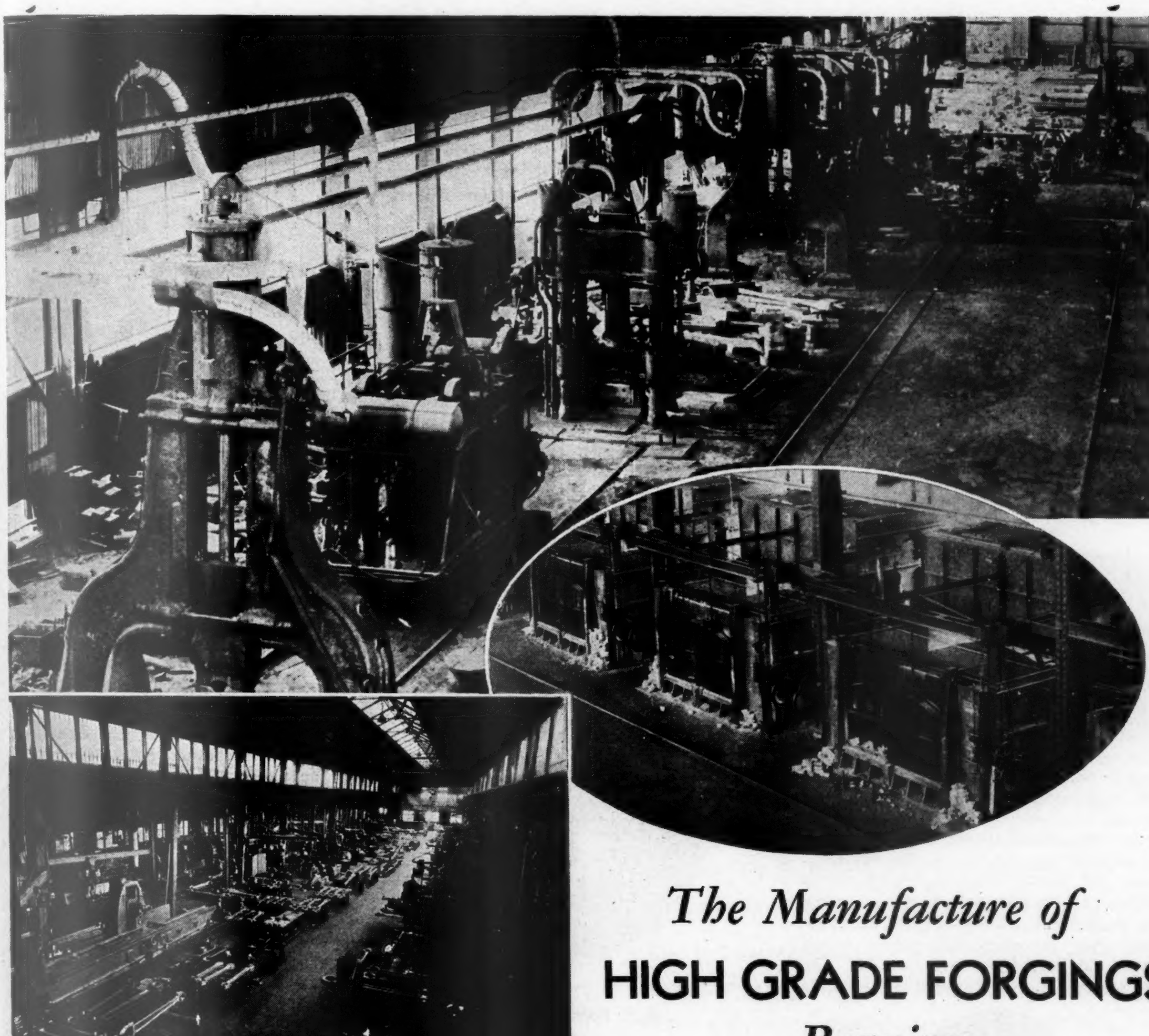
GEORGE KIRTLEY, assistant to the vice-president of the Plymouth Locomotive Works, division of The Fate-Root-Heath Company, Plymouth, Ohio, has been appointed sales manager of the Locomotive Division, and Roy J. Johnson, assistant chief engineer, has been appointed assistant sales manager.

J. R. FRAINE has been appointed assistant manager of sales of the Republic Steel Corporation, wire division for the northern territory, with headquarters at Chicago. Carl C. Brown, district sales manager at Birmingham, Ala., has been appointed assistant manager of sales of the wire division, at Birmingham.

◆

C. D. CAREY, who has been handling railway sales for the Gulf Oil Corporation and its subsidiary the Gulf Refining Company, Pittsburgh, Pa., has been appointed manager of railway sales for both companies, with headquarters at Pittsburgh. Mr. Carey is a graduate of Princeton University and Massachusetts Institute of Technology. He gained his first railway experience while working under Dr. P. H. Dudley, consulting engineer of the New York Central lines and while employed in the metallurgical and railway sales department of the Bethlehem Steel Company. Later he served as associate

(*Continued on next left-hand page*)



engineer physicist, investigating the causes of rail failures for the U. S. Bureau of Standards. For several years he was assistant to the president of the Standard

C. D. Carey

Motor Truck Company and the Verona Steel Castings Company, subsidiaries of the Standard Steel Car Company. During the war he was in charge of the Pittsburgh district for the R. W. Hunt Company.

◆

J. C. McCune, assistant director of engineering of the Westinghouse Air Brake Company, has been appointed to the newly-created position of director of research, with headquarters at Wilmerding, Pa. Mr. McCune was graduated from Cornell University in mechanical engineering in 1911. He entered the employ of the Westinghouse Air Brake Company in 1913, as assistant to the chief engineer and, after two years, was transferred to the New York office as mechanical expert, which position he held from 1915 to 1917. He then served on the Mexican border with

J. C. McCune

the seventh regiment New York National Guards, and later in the World War as first lieutenant of engineers of the United States Army, with 10 months' service in France. At the conclusion of the war, he returned to the Westinghouse Air Brake Company as a special engineer at Wilmerding. In 1920 he returned to the New York office as assistant to the district engineer, and a few months later was made assistant district engineer. In 1922 he was promoted to the position of district engineer. A further promotion came in 1926, when he returned to Wilmerding to serve as assistant director of engineering, which position he held until his recent appointment as director of research.

◆

Several changes in the Hunt-Spiller Manufacturing Corporation, South Boston, Mass., organization were made effective February 1. R. F. Harrington, metallurgist, has been promoted to chief metallurgist and will also superintend foundry operations. He was graduated from Tufts College in 1913 with the degree of bachelor of science in chemical engineering. Serving first as a chemist he has been metallurgist during the past 15 years, in which capacity he developed the metallurgical and research department. He has been succeeded as metallurgist by A. S. Wright, formerly assistant metallurgist, who has been in the service of the corporation since his graduation from Northeastern University in 1914. A. H. Lindsay,

Jordan Marsh Co.

R. F. Harrington

who has been associated with the corporation for 32 years, was appointed assistant foundry superintendent. Joseph Goostray was appointed mechanical superintendent, in charge of maintenance and operation of mechanical and electrical equipment and of all departments in which finished machined products are manufactured. A graduate of Northeastern University, he entered the service of the corporation in the pattern department. During the World War he was a chief petty officer in the United States Navy and served as chief draftsman in the Engineer and Repair Office at the U. S. Submarine Base at New London, Conn., returning to the Hunt-Spiller Corporation at the close of the war. H. E. Barber, a graduate of Lowell Institute in 1924, succeeded Mr. Goostray as mechanical engineer.

◆

V. R. Willoughby, general mechanical engineer of the American Car and Foundry Co., has been elected to the newly created office of vice-president in charge of engineering. He will continue to exercise general supervision over the engineering department, but will devote more time to design and development work, in addition to carrying on his railroad and other technical committee activities. E. D. Campbell succeeds Mr. Willoughby as general mechanical engineer, with headquarters at New York. W. F. Dietrichson becomes assistant general mechanical engineer in charge of engineering activities at the Berwick, Pa., plant. This position was formerly held by Mr. Campbell.

Mr. Willoughby received his college education at the University of Michigan, in the class of 1896, receiving a B.S. de-

V. R. Willoughby

gree in mechanical engineering. Immediately after graduating, he went to work with the Solvay Process Company. In October, 1897, he joined the Michigan Peninsular Car Company, one of the predecessors of the American Car and Foundry Company, and two years later, served at St. Louis, Mo., as assistant to the mechanical engineer. In 1901 he was transferred to the St. Charles plant of the American Car and Foundry Co., in the department of passenger car design, and in 1905, was appointed local engineer to Jeffersonville, Ind., plant of the American Car and Foundry Co. From October, 1917, Mr. Willoughby took an active part

E. D. Campbell

in wartime activities of the American Car and Foundry Co., serving in the artillery and shell departments. In September, 1919, he came to the New York office in the operating department; in August, 1920, he was appointed assistant general me-

(*Continued on next left hand page*)

chanical engineer and in April, 1921, acting general mechanical engineer in New York. Since January 1, 1924 he has been general mechanical engineer of the American Car and Foundry Co., now becoming vice-president in charge of engineering. Mr. Willoughby is a member of the American Society of Mechanical Engineers, and the American Society of Testing Materials. He is the inventor of many patented devices.

Mr. Campbell was educated in the Berwick, Pa., public schools and Penn State College, graduating in mechanical engineering course in the class of 1903, and in 1907, he received a master's degree of M.E. from that institution. After graduation, he served a short apprenticeship in steel car shops in the plant of the American Car and Foundry Co., at Berwick. During the years of 1905 to 1908 inclusive, he worked in the engineering department of the American Car and Foundry Co. at Berwick, and later in New York and Milton, Pa. In the fall of 1909, he went to St. Louis, Mo., to assist the chief mechanical engineer of the American Car and Foundry Co. and continued in that office until May, 1917. During the World War, he was commissioned captain in the Engineer Officers Reserve Corps and later was assigned to the Engineering Division of the Ordnance Department in Washington. In May, 1918, he was promoted to major; in 1919 he was commissioned lieutenant-colonel in the Ordnance Reserve Corps and in 1931 was advanced to colonel. After his discharge from the army in June, 1919, Mr. Campbell returned to the American Car and Foundry Co. as assistant engineer in the New York office. In 1925 when the St. Louis plant was expanding, he went to St. Louis to organize the mechanical department. In August, 1933, he was promoted to assistant general mechanical engineer at the Berwick plant, now becoming general mechanical engineer.

◆

Frederick T. Robertson has been appointed vice-president of the Lewis Bolt

Frederick T. Robertson

& Nut Co., Minneapolis, Minn. After obtaining his engineering degree, Mr. Robertson was employed by the Canadian Pacific and the Chicago, Burlington & Quincy. Later he worked for Consoer, Older & Quinlan, consulting engineers, Chicago, and for the last six years has been in the employ of the Lewis company.

Obituary

Charles Waterman Stone, consulting engineer of the General Electric Company, died at his home in Schenectady, N. Y., on February 3, at the age of 63 years.

◆

Charles Augustus Ives, for many years in charge of air brake commercial and engineering activities of the General Electric Company, died on January 27, at his home in Erie, Pa. Mr. Ives was born at Racine, Wis., on August 7, 1879, and obtained his education in the public schools. He served with the Chicago, North Shore & Milwaukee, in the shops at Chicago and later was with the National Air Brake Company. In 1906 he took up his first work with the General Electric Company in the sale and servicing of air brake equipment; the following year he went to Schenectady, N. Y., for similar activity in the Railway Equipment division, transferring to the commercial department in 1908. His duties included both sales and service in connection with air brakes and air compressors. In 1914, Mr. Ives moved, with other members of the department, to the Erie works of G. E., where he was in charge of all commercial and engineering work on air brake equipment.

Personal Mention

Master Mechanics and Road Foremen

P. O. Christy has been appointed master mechanic of the Illinois Central at Paducah, Ky., to succeed R. R. Royal.

A. D. Haley has been appointed assistant master mechanic of the Illinois Central at Markham shops, Hazel Crest, Ill., succeeding P. O. Christy.

Henry M. Sherrard, mechanical inspector on the staff of the superintendent of motive power, Western lines of the Baltimore & Ohio, has been appointed master mechanic of the Monongah division, Eastern lines, with headquarters at Grafton, W. Va., succeeding R. H. Cline, resigned.

John J. Mellen has been appointed district master mechanic of the Cleveland, Cincinnati, Chicago & St. Louis, with headquarters at Indianapolis, Ind. Mr. Mellen was born on November 19, 1890, at St. Louis, Mo. He attended the public schools at Mattoon, Ill., and on August 10, 1907, entered the employ of the C. C. C. & St. L. as machinist apprentice at Mattoon. Upon the completition of his apprenticeship in August, 1911, he served as a machinist on the Chicago & Eastern Illinois at Danville, Ill., and Villa Grove; on the Illinois Southern at East St. Louis, and on the C. C. C. & St. L. at Mattoon, until September, 1914. The following month he became enginehouse foreman at Mattoon; in March, 1917, enginehouse foreman at Mt. Carmel, Ill.; in September, 1917, enginehouse foreman at Bellefontaine, Ohio; in March, 1918, general foreman at Bellefontaine; in June, 1922, general foreman

J. J. Mellen

at Linndale, Cleveland, Ohio; in January, 1923, master mechanic of the Cincinnati Northern at Van Wert, Ohio; in March, 1930, assistant master mechanic of the C. C. C. & St. L. at Bellefontaine, and in August, 1932, general foreman at Bellefontaine. From February, 1933, until January of this year he was master mechanic of the Cincinnati Union Terminal Co. at Cincinnati, Ohio. Mr. Mellen organized the locomotive, car, stores and maintenance departments of the Cincinnati Union Terminal which was opened in March, 1933. He also organized the maintenance of equipment forces for the opening of the new Cleveland Union Terminal in 1930.

Shop and Enginehouse

E. C. Roddie, shop superintendent of the Illinois Central at Paducah, Ky., has retired.

R. R. Royal has been appointed shop superintendent of the Illinois Central, with headquarters at Paducah, Ky.

Obituary

Mark Purcell, general air brake inspector of the Northern Pacific, with headquarters at St. Paul, Minn., died suddenly on February 8. Mr. Purcell was born on March 21, 1869. He entered the service of the Northern Pacific in 1889 in the enginehouse at East Grand Forks, Minn. After advancing successively through the positions of locomotive fireman and engineman, he became air brake instructor and then assistant general air brake inspector. He had served as general air brake inspector at St. Paul since June 1, 1911.